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UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Assistant in Personnel Research.

Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than June 26th. The date for assembling of competitors will be stated on their admission cards, and will be about fifteen days after the close of receipt of applications.

The examination is to fill vacancies in the Research Division of the United States Civil-Service Commission, Washington, D. C., and in positions requiring similar qualifications.

There are three grades of assistants. The entrance salaries are $1860 a year for Grade 1 positions, $2400 a year for Grade 2 positions, and $3000 a year for Grade 3 positions. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions.

The duties in general will be to assist in research with a view to evaluating and improving methods of selection and placement and to developing new technic in the construction and standardization of improved examinations and tests for entrance to and promotion in the Federal service. The duties of the positions of the two upper grades will include, in addition, studies in the technic of investigation work and in the development of training methods, as well as a study of the findings of personnel research undertaken outside of the Commission, for the purpose of formulating principles of research.

Competitors will be rated on a mental test, and their education and experience.

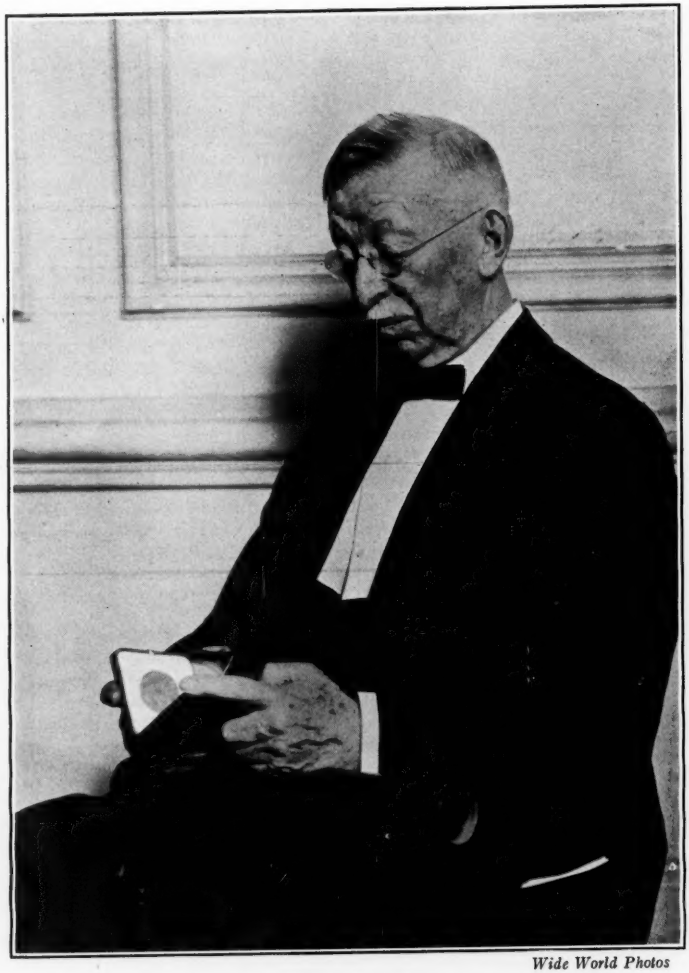
Full information may be obtained from the United States Civil-Service Commission at Washington, D. C., or the secretary of the United States civil-service board of examiners at the post-office or customhouse in any city.

Household Chemical Travels under Aliases. Tri-sodium phosphate, one of the most valuable household chemicals ever discovered, apparently has no press-agent and so far has escaped the notice of madam housekeeper. If she uses it, at least she does not know it. A survey of the Los Angeles wholesale chemical market, however, shows large quantities of the phosphate going out quietly, soon to emerge under a variety of fancy labels, with various colors and at enhanced prices. Much of this material is adulterated with cheap washing soda.

As a washing powder tri-sodium phosphate has proved to be a remarkable preparation. Its degree of alkalinity is distinctly higher than that of common washing soda, but not high enough to cause damage to dry paint.

The main alkaline strength of the phosphate lies in reserve, due to the unique chemical constitution of the substance. It is the reserve feature which makes it equal in many situations to caustic soda as far as dirt riddance is concerned. For steam-cleaning of automobile chassis; cleansing of greasy hands of mechanics, and of furniture subject to much public handling; riddance of scum on lavatories and tubs, and for water-softening the phosphate is proving very effective.

In view of the current American wholesale price of four to six cents per pound (according to location) it is thought that tri-sodium phosphate should find a place on the grocer's shelf under its own name. It is not patented or subject to private control. It is not poisonous or offensive, and requires no chemical skill in handling. There seems to be no good and permanent reason why it should appear solely under meaningless trade-marks any more than should salt or sugar.—*Science Service*



Wide World Photos

DR. EDGAR FAHS SMITH

EDITOR'S OUTLOOK

WHEN Dr. Edgar Fahs Smith passed on to join the immortals whose lives and works had always held for him such an absorbing interest, American chemistry suffered the loss of one of its best-beloved and most charming devotees. He will take his place in the history he loved so well as an eminent chemist whose long and active lifetime was filled with notable achievements. Yet those who knew him will remember him primarily as a remarkable and a delightful personality. John C. Bell, an alumnus of the University of Pennsylvania and an associate of Dr. Smith's for many years, said of him:

Dr. Edgar Fahs Smith

> . . . . . With him the observance of the greatest of all commandments—"Love thy neighbor as thyself"—is instinctive. The personification of unselfishness, his countless deeds of kindness and charitable gifts to the needy and deserving, and especially, during his long term of service, to numberless struggling students of our University—will, in accord with his expressed desires, doubtless never be told here; but they are all surely registered in Heaven. Incapable of an unkind act—yes, I believe, of even an unkind thought, I personally never have known a more nearly Christlike man than Doctor Edgar Fahs Smith.

The fragrance of that personality is to some extent preserved to us in the biographical and historical writings which were the product of his chief avocation. His interest in chemical education and his contributions toward its advancement are too well known to readers of the JOURNAL to need recounting here. They are duly noted elsewhere in this number by Dr. C. A. Browne.

Dr. Browne advances a suggestion which we desire to second most heartily. It is that Dr. Smith's office with its priceless collection of portraits, documents, and chemical relics of every description, be preserved just as he left it—not only for its own value but as a fitting memorial to the man, and a recognition of his own wishes. We are told that recommendations to that effect have already been placed before the trustees of the University.

For the photograph of the Edgar F. Smith statue which accompanies Dr. Browne's tribute we are indebted to Miss Armstrong, Dr. Smith's secretary. The other two photographs were procured for us by Mr. William Rogers.

AMONG the clippings which we preserve for the purpose of stimulating an occasionally jaded editorial muse, we find a short essay by Dr. Glenn Frank, entitled "The Evangelism of Science." Dr. Frank's

Science Reshaping the World

plea (which we endorse) is for more and better interpreters of science. He says, in part:

> All the sciences have lying, relatively unused, in their laboratories socially usable ideas that would, if really used, lift the whole tone and temper of American life.
>
> Unfortunately many of these ideas are today buried under the jargon of technical scholarship and effectively insulated from contact with our common life.

No doubt Dr. Frank is right. Yet one is led to wonder just what some of these socially usable ideas may be. Although he speaks of "all the sciences," it does not seem to us that he could have had special reference to those of the physical group. Most of their "socially usable ideas" find prompt commercial exploitation today—too prompt, sometimes. Through such exploitation they affect the tone and temper of American life long before the man in the street understands them, if he ever does. Those which fail of exploitation usually do so because of economic or other reasons, rather than because of ignorance on the part of the persons capable of promoting them.

It may be that Dr. Frank was thinking more particularly of the "social sciences" (although he speaks of laboratories). Unfortunately, about the best we can do in dealing with social problems is to maintain a scientific attitude of mind. Few of the results of social investigation can be promulgated as discoveries or demonstrations of scientific truths.

Not so many years ago it was held in some quarters that universal education would usher in the millenium. We have not yet reached the goal of universal education but we have traveled far enough along the road to see that the millenium lies still beyond. Some of the claims which are today being made for science and scientific education are just as extravagant as those which were once made for education in general. Our modest hopes (and to be reasonable they must be modest) should be pinned upon the possibility of a wider diffusion of the scientific attitude of mind rather than upon wider publicity for the facts of science.

To quote from one of Simeon Strunsky's weekly essays in a recent number of the *New York Times Book Review:*

> It is just as desirable and possible under Einstein and Bohr and Planck, as it was under Newton and Copernicus, as it was under Ptolemy and Moses, to work for a living, treat your neighbors decently, feed your children and not grunt at your wife when she asks you about something in the newspaper at breakfast. . . .
>
> . . . Ultimately the new discoveries of science, no matter how distant or refined, will insist on shaping your daily lives; but they will do so without your worrying or without taking count of your sympathy or interference. . . . It is premature to be asking yourself what will the electron do to the marriage code and the system of capitalistic production. What the electron will do may very well turn out to be plenty; but it will do it in its own good time and in its own way.

Science is reshaping the material world but it is not as yet prepared to offer any social panaceas.

CHEMICAL INDUSTRY*

ARTHUR D. LITTLE, ARTHUR D. LITTLE, INC., CAMBRIDGE, MASSACHUSETTS

Mr. Aldred, the distinguished founder of this course of lectures, has given many proofs of his exceptional sagacity. Conspicuous among them is the fact that immediately upon my acceptance of the invitation to speak to you he left the country. The date of his return will doubtless be determined by the character of your reception of what I have to say to you.

Sir Alfred Mond, who for a generation has been an outstanding figure in the chemical industry of Great Britain, said recently, "If we analyze the ordinary doings of the ordinary man throughout the twenty-four hours, we find that all the objects with which he deals and most of the food he eats have come, at some time or other, within the province of chemical industry."

A witty Frenchman long ago remarked: "No general statement is ever true. Not even this one." I am confident, however, that the entire accuracy of Sir Alfred Mond's conclusion can readily be established and I am therefore justified in assuming that in selecting chemical industry as my subject I have taken one in which each one of you has a very direct interest quite irrespective of the particular profession for which you are preparing yourself.

I hope also to convince you that, whatever your course of professional study may be, the field of chemical industry is so broad and its demands so varied that it affords you ample scope for your specialized activities.

It may be that in the minds of some of you chemical industry is limited to the manufacture of acids, dyes, and so-called chemicals. In reality it comprises any industrial operation in which the essential nature, rather than the mere form, of the materials involved is changed. Chemistry is not immediately concerned with cutting down a tree and putting it through a sawmill, but it at once comes into play when the wood is reduced to pulp by cooking with caustic soda or bisulfites, and again when the wood pulp is converted into cellulose compounds from which artificial silk may be derived.

The sinking of an oil well is not, in itself, a chemical operation, but the cracking of the oil for its conversion to gasoline is one. So, again, the process by which Frasch brought up molten sulfur from beneath five hundred feet of Louisiana quicksand is not a chemical process, though conceived by a chemist and applied to the recovery of a basic chemical raw material, but that other process, whereby Frasch removed the objectionable sulfur from Ohio oils by distilling them over copper oxide with which the sulfur combined, is a chemical operation of a typical sort.

* Aldred Lecture delivered at the Massachusetts Institute of Technology, March 23, 1928.

All this is, of course, well known to most of you, and I only venture to recall it because my friend and classmate, the late Dean Talbot, once said to me, "Nothing is so volatile as Freshman Chemistry."

Chemical industry in any comprehensive sense is a development of the last one hundred years. In ancient Egypt, Mesopotamia, Greece, and Rome it was represented by little more than a crude metallurgy, glass-making, dyeing, tanning, lime-burning, and the production of beer and wine. The lists that have come down to us of occupations in medieval Paris during the eleventh and thirteenth centuries are similarly restricted in their reference to activities of a chemical sort. Even as late as 1800 in England and on the Continent chemical industry in any general sense was practically non-existent, though there was a well-developed metallurgy, much dyeing of a simple sort, some manufacture of gunpowder, and of course much brewing and tanning.

Chemical industry, as we know it, may be said to have begun with the discovery, in 1791, by the French chemist, Le Blanc, of a process which permitted the cheap production of sodium carbonate and caustic soda from common salt. Sodium carbonate or soda has been known from the earliest times as a deposit called "nitre," on the shores of the soda lakes of Egypt, but the chief source of alkali was the *barilla*, prepared in Spain from the ashes of marine plants. The supply was, however, so inadequate that the French Academy, in 1775, offered a prize for the production of alkali from salt. This was won by Le Blanc in 1791. The manufacture started in 1793 in a factory which was soon thereafter confiscated by the Committee of Public Safety. As a most deplorable consequence Le Blanc died by suicide in a French poorhouse.

The process was, however, taken up in England and became the foundation of the great British alkali industry with its many collateral products. Le Blanc utilized, as you know, sulfuric acid to decompose the salt. This acid, or oil of vitriol, had been known since the fifteenth century and is today the corner stone of the chemical industry. The chamber process for its manufacture had been operated in a small way in England since 1746, but now production rapidly expanded to meet the demands of the Le Blanc process.

Meanwhile, the great development of the cotton industry, made possible by the new textile machinery of Arkwright, Hargreaves, Crompton, and others, and stimulated by Watt's invention of the steam engine, created an intensified demand for alkali and acid and for improved bleaching agents. This demand was further augmented by the rapid growth of the paper industry which resulted from the development, about 1800, by Robert and Fourdrinier, of the machine now everywhere in use for making paper in a continuous web.

The relation of the Le Blanc process to the art of bleaching developed

in this way. For a long period down to the middle of the eighteenth century the Dutch had possessed a monopoly of the bleaching trade. The long series of operations involved kept the goods out of the merchants' hands for seven or eight months. The cloth was steeped in alkaline lye, washed, and spread on the grass for weeks, and this tedious procedure was repeated five or six times. It was followed by steeping in sour milk, more washing, and renewed exposure to the sun.

The first improvement in this long, standardized program was the substitution of dilute sulfuric acid for the sour milk. Like most innovations it met with much resistance, but one more radical was soon to follow. Chlorine had been discovered by Scheele in 1774 and its applicability to the art of bleaching demonstrated by Berthelot in 1785. A year later he brought his results to the attention of James Watt, who immediately introduced the method into England. The employment of chlorine as a gas under the conditions then existing involved many objectionable features and made slow progress until Charles Tennant, in 1799, brought out bleaching powder made by absorbing the gas in slaked lime.

Scheele had made chlorine by treating manganese dioxide with hydrochloric acid, and in the Le Blanc process torrents of this acid gas are produced through reaction of the sulfuric acid and the salt. The nuisance was so great as to become the subject of restrictive legislation, which forced the alkali makers to convert a stumbling block into a stepping-stone by utilizing their hydrochloric acid as a raw material for bleaching powder. This was done in an imperfect way at first, but later most efficiently by the classical Weldon process. Gradually other by-products were developed until the alkali industry was represented by huge plants in England, France, and Germany, which supplied the world with the essential heavy chemicals.

In 1838 a process for making soda by passing carbonic-acid gas into a solution of common salt in ammonia was patented in England by Dyar and Hemming, but not until 1872 were its serious engineering difficulties overcome by Ernest Solvay of Belgium and his improvements embodied in the Solvay process, which gradually supplanted that of Le Blanc.

In 1851 Charles Watt took out a remarkable British patent, in which the procedure necessary for the production of chlorine, hypochlorites, chlorates, and alkali by the electrolysis of a solution of salt was defined with a precision extraordinary for the time. Unfortunately, Watt's only source of current was the expensive electric battery, and his disclosures were without commercial value and were soon forgotten. In 1890, however, Ernest A. Le Sueur, in the course of his thesis work as a student at the Massachusetts Institute of Technology, developed the first commercially practical cell for the electrolytical production of chlorine and alkali from salt. A plant of his design was erected at Rumford Falls, Maine,

and operated successfully for several years. Unfortunately, its management failed to recognize that they had entered a new field in which alternative processes were certain to develop, and where their lead could only be maintained through continued intensive research. The Le Sueur process was consequently soon supplanted by others which are now in operation on the great scale and in serious competition with the Solvay process by which no chlorine is produced.

The rough outline here presented of the development of the alkali industry is typical of chemical industry in general and serves to illustrate the factors upon which its growth depends. A specific chemical industry has its origin in a discovery in the laboratory. Its early development is commonly beset with difficulties. It grows through the reaction upon it of developments in other industries and through the conversion of its wastes into valuable by-products. It has no assurance of stability other than that furnished by continued research and the studied consideration of the trend of scientific progress and industrial development. When, however, competent technical ability is adequately backed by educated money and both made subject to wise business management, chemical enterprises have shown remarkable earning power and a capacity for growth of which the du Pont company in this country and the I. G. in Germany are the outstanding examples.

Chemical industry in Germany developed upon broader lines than in England and during the period preceding the war was more varied and extensive than in any other country. Its foundations were laid by those great leaders in chemistry with whose names you are all familiar, and who were assisted by an army of capable but less gifted scientific workers in university and corporation laboratories. The methodical German mind early turned its attention with especial aptitude to the field of organic chemistry, and this interest was greatly stimulated by the synthesis of the dyestuff, mauve, by Perkin, in England, in 1856, from aniline, a derivative of coal tar. The significance of this discovery was not fully recognized in England, but its importance was at once appreciated in Germany, where it stimulated the brilliant and long-continued research upon which the great coal-tar color industries were built up.

Through recent consolidations and agreements the Germans have now created that colossus of the chemical world known as the I. G., or, more exactly, the *Interessengemeinschaft Farbenindustrie Aktien-Gesellschaft*, the interests of which are now so varied that it reaches not only into every industrial section of Germany, but also into foreign countries. It controls large coal and lignite mining properties. It manufactures not only dyes, but chemicals of every kind, including fertilizers and explosives. It is interested in the manufacture of aluminum, artificial silk, and photographic supplies. It produces motion pictures, controls oil and sugar refineries,

besides owning its banking, building, and real estate agencies. It owns from 50 to 100 per cent of 66 corporations in these and other fields, and 50 per cent or less of 50 other companies, a total of 116. Among notable recent developments which it controls are the famous Bergius process for the liquefaction of coal and the still more famous and highly developed Haber process for the fixation of atmospheric nitrogen in the form of ammonia. Of the present production of 600,000 tons of nitrogen in Germany 440,000 were by the Haber-Bosch process of the I. G.

Dr. Haber attributes the success of the German chemical industry to the fact that from its commencement the Germans realized the need for the close coöperation of the chemist, the technician, and the selling department. The chemist must interest himself in the selling side if he wishes to understand the business in which he is engaged. If he confines his interest to the scientific side he loses a great opportunity. Dr. Haber advises the chemist in industry to forget at times that he is a unit in a profession, and remember always that he is a unit in a business.

A recent editorial in *Chemistry & Industry*, London, gives expression to the same thought in these words, "Personally, we think the main need now in industry is greater knowledge by the business men of chemists and their work, and by the chemists of the methods and ambitions of the business men."

The development of chemical industry in America went forward more slowly than in Europe, but had already attained important dimensions along somewhat restricted lines when it was greatly stimulated by the war. We immediately found ourselves in need of the dyes and important organic chemicals for which we had depended upon Germany, and we were called upon to create vast works to meet the imperative and multitudinous demands of the military establishment and of our allies. Our manufacturers were, moreover, alert to capture markets formerly supplied by Germany, while our people as a whole came to a realization that a strong and highly developed chemical industry is vitally essential to national security.

Under this urgent pressure of immediate necessity our chemical industry, which did not, in this instance, obey the gas laws, expanded rapidly to proportions which now make it the most extensive in the world. Concurrently with this advance there grew up in the minds of the financier, the industrial executive, and the man in the street a more adequate appreciation of the chemist as a keystone in the industrial structure and of research as the price of progress.

Among the multitude of companies that reacted to the stimulus of the war demand none stands out more conspicuously than E. I. du Pont de Nemours & Co., Incorporated. It was, for that company, a wholly normal reaction in view of its origin and history. In 1800 E. I. du Pont came to this country from France with his father and brother. He had served

under Lavoisier, the Father of Chemistry, in the French powder works at Essonne. Coming here with the intention of developing a great tract of land in Virginia, he was struck by the poor quality and high price of the American powder purchased for a day's hunting. He realized that an opportunity lay before him, purchased the necessary machinery in France, and in 1802 began building the first du Pont powder mills along the banks of Brandywine Creek, near Wilmington, Delaware.

Continuously thereafter the activities of the company have been closely identified with the history and progress of the United States. In our earlier days gunpowder was a vital necessity to the hunter and the pioneer, while in later times explosives of greater power have been equally essential to the quarryman, the miner, the farmer, and to engineering projects from the blowing up of Hell Gate Rock to the building of a railroad or the cutting of the Panama Canal. In 1921 the United States produced and used for industrial purposes 538,000,000 pounds of explosives, and we may assume that a great proportion of this was the product of the du Pont company.

In our war with Tripoli, as with Commodore Perry on Lake Erie and with General Scott in the Mexican War, it was du Pont powder that charged our guns, as it did again during the Civil War.

In 1863 the Swedish chemist, Alfred Nobel, prepared nitroglycerine by passing glycerine in a slow stream into mixed nitric and sulfuric acids. Being a liquid, it was inconvenient and dangerous in use. Nobel overcame these objections in 1866 by absorbing the nitroglycerine in kieselguhr, a diatomaceous earth, for which later wood flour was substituted, and in 1878 he brought out blasting gelatine made by combining nitroglycerine and nitrocellulose.

These inventions were quickly taken up and further developed by the du Pont company, as were the later smokeless powders and the high explosives such as T.N.T.

The extraordinary extent to which the facilities of the company were expanded to meet the demands imposed upon them by the exigencies of the war is shown by the fact that whereas the annual capacity of its plants for military powder was 8,400,000 pounds in 1914, this capacity was increased during the war to 440,000,000 pounds.

Nitrocellulose was first prepared by Schönbein in 1846, and few discoveries have had a more profound effect upon human history or more varied industrial applications. It led directly to collodion, photographic films, artificial silk; to celluloid, guncotton, and smokeless powder; to artificial leather and, most recently, to pyroxylin lacquers and varnishes of the type conspicuously represented by Duco, which are now finding general application as automobile finishes and as a substitute for paint and varnish for interior work and furniture. The production of these lacquers, which was less than $1^1/_2$ million gallons during the first half

of 1924, had risen to more than 10 million gallons in the first six months of 1926.

The du Ponts, early in the present century, very naturally turned their attention to the production of nitrocellulose products other than smokeless powder and first brought out a pyroxylin-coated fabric, which finds extensive use as artificial leather. The easy step from this to rubber-coated fabrics was taken in 1916.

In 1917 they entered the broad field of pyroxylin plastics in competition with celluloid. They proceeded to the manufacture of motion-picture films in 1923 and to the production of the Duco finishes a few months later. In 1920 they began the manufacture of artificial silk from another cellulose compound known as viscose, to which I shall again refer.

In 1923 the experience gained with viscose was further utilized in the production of Cellophane, a form of cellulose in excessively thin, transparent sheets which are principally used in wrapping packaged articles of luxury.

Previously, in 1917, there had been acquired by the du Ponts the accumulated facilities of a large corporation which, for more than one hundred years, had been developing the manufacture of paints, pigments, and an extensive line of chemicals. Other plants for the production by high-pressure processes of synthetic ammonia and the solvent methanol have recently been erected.

I have endeavored in this inadequate review of the growth of the du Pont company to indicate the manner in which the logical interests of an enterprise originally concerned only with the manufacture of black powder led it progressively to undertake the production of smokeless powder, nitroglycerine, dynamite, and high explosives, and to proceed to its present widely diversified output of chemically related products. In this development the company has employed at one time as many as 1200 chemists and spent in a single year $3,000,000 in research. On its staff there are, moreover, construction engineers, civil, mechanical, electrical, power, and mechanical research engineers, architects, structural and machine designers, and heating and ventilating engineers. As the company has recently undertaken the production of alcohol and glycerine by fermentation processes I have no doubt that biologists are now also on its pay roll.

While these two great aggregations of chemical enterprises, the du Pont company and the I. G., may represent the utmost yet achieved in chemical industry, there are many other notable examples of the creative influence and earning power of chemistry. Brief consideration of the origins and present status of a few of these should prove instructive. Particularly will they serve to indicate the general order of magnitude of the values which have been developed from specific chemical discoveries.

The metal aluminum was discovered in Germany by Wöhler in 1828.

It cost, in 1855, $90 a pound. In 1886 it had fallen to $12. The American Castner process brought the price, in 1889, to $4. Even at this figure it was obviously still a metal of luxury with few industrial applications. Then, simultaneously, Heroult in Europe and Charles M. Hall, a student at Oberlin College, Ohio, discovered that cryolite, a double fluoride of aluminum and sodium, fused readily at a moderate temperature, and, when so fused, dissolved aluminum oxide as boiling water dissolves sugar or salt. By passing an electric current through this solution they obtained the metal.

On August 26, 1895, the Pittsburgh Reduction Company started at Niagara Falls the manufacture of aluminum under the Hall patents. In 1911 the market price of the metal was 22 cents and the annual production 40,000,000 pounds.

The Pittsburgh Reduction Company was later reorganized as the Aluminum Company of America, a corporation with $60,000,000 in 5% debenture bonds, $150,000,000 in 6% preferred stock, and 1,500,000 shares of no par value common stock. For ten years ending December 31, 1926, the net income of the company, after taxes and depreciation, averaged over $12,000,000, and in 1925 it was $22,891,505.

Allied Chemical & Dye Corporation came into being in December, 1920, through the consolidation of five companies, which, together, were then engaged in making coke, alkali, acids and other heavy chemicals, dyes, and various products from coal tar.

On December 31, 1927, the corporation had outstanding over $39,000,000 in 7% preferred stock, 2,178,109 shares of no par value common stock, and had a net working capital of more than $136,000,000. The stock-market value of its common stock at the close of business March 16, 1928, was over $340,000,000.

In 1889 Count de Chardonnet exhibited at the Paris Exposition of that year the first samples of artificial silk. They were made by squirting a solution of nitrocellulose through extremely fine orifices. After many discouragements the process was finally placed upon a very profitable commercial basis, though certain defects inherent in the product prevented its broad acceptance.

In 1893 Messrs. Cross, Bevan & Beadle, of London, who were already distinguished for their contributions to cellulose chemistry, discovered what is known as the viscose process. In this process cellulose, in the form of cotton fiber or wood pulp, is exposed to the conjoint action of caustic soda and bisulfide of carbon and thereby converted into a compound which is plastic and soluble in water. This compound, called viscose, is readily decomposed with recovery of the cellulose in the form imposed upon it while in the plastic and soluble state.

The discovery has received numerous important industrial applications. I will here refer to only one of these, namely, the manufacture of viscose

artificial silk, now commonly called "rayon." The world production of rayon of all types, in 1927, was 265,900,000 pounds, of which 80% is believed to be viscose rayon.

Courtaulds, Limited, of England, are the largest manufacturers, operating plants in several countries including our own. The capital structure of Courtaulds, Limited, was, when I began to prepare this lecture, £12,000,000 in ordinary shares and £8,000,000 in 5% preferred shares. Within the last few days, however, the fortunate holders of its ordinary shares have received a 100% stock bonus. Previous dividends paid on the ordinary shares from 1914 through to March 11, 1927, reached a total of 597½%, or an average of 46% a year on approximately $60,000,000.

During the early years of my professional practice one of the outstanding problems of industrial chemistry was that of removing the sulfur present in the petroleum of the Lima, Ohio, field. Because of its high sulfur content the oil was considered only fit for fuel and was being sold at 14 cents a barrel. Herman Frasch solved the problem by demonstrating that by distilling the oil in the presence of finely divided copper oxide a sweet distillate, practically free from sulfur, was obtained. As a result of this demonstration, the price of this crude advanced to nearly $1.00 a barrel and fluctuated between 60 cents and $1.00 for a great many years. As the daily production of the field was 90,000 barrels the value added to its output by the Frasch process may be reasonably put at $45,000 a day.

In 1828 Wöhler synthesized urea, and in 1863 he prepared for the first time calcium carbide in small quantity as an amorphous powder. The compound had no industrial significance, however, until 1893, when Willson, in this country, produced it in massive crystalline form by heating lime and coke in an electric furnace. Let us note what followed.

Willson is said to have discovered accidentally that his carbide decomposed on contact with water with evolution of an inflammable gas, which proved to be acetylene. Soon acetylene generators were in common use for lighting isolated homes, sometimes with disastrous result. I remember, however, that the negro in charge of the cabin which I once occupied in the Maine woods assured me that the gas was perfectly safe because it was "home-made."

Next, Claude and Hess discovered that acetone dissolved about 700 times its volume of acetylene and that a cylinder packed with asbestos, which was then saturated with acetone, would hold, and without danger of explosion, more acetylene, at a given pressure, than could be forced under the same pressure into an empty cylinder. Then we had The Prest-O-Lite Company, Inc., and the cylinders known as Prest-O-Lite tanks, once part of the equipment of every automobile and still widely used in oxy-acetylene welding.

The Union Carbide Company was incorporated in 1898 and manufac-

tured carbide at Niagara Falls and elsewhere. It later became one of the thirty or more subsidiaries of Union Carbide and Carbon Corporation, which, through these subsidiary companies, is involved in the manufacture of a wide range of electric-furnace products and synthetic organic chemicals, many of which are derived from acetylene. Among the products of its many collateral activities are coal and coke, metals and alloys, liquid air, oxygen and nitrogen, batteries, and carbons for arc terminals, brushes, and electrodes.

The relation of liquid air to calcium carbide, though not immediately obvious, is nevertheless directly concerned with another and especially important development of chemical industry.

At the beginning of the present century the world was faced with the stupendous problem of finding an adequate and continuing supply of nitrogen in forms available to plants as food and to the industries for the manufacture of explosives and many other essential products. We were warned by so distinguished a scientist as Sir William Crookes that the problem was one which the world must solve or starve. Practically all of our available nitrogen reserves were contained in the nitre beds of Chile, and the exhaustion of these was believed to be a matter of a few decades at most.

Some progress toward a solution of the problem had been made by Birkeland and Eyde in Norway, where, in 1905, they began the production of nitrates by passing air through enormous flaming and rotating electric arcs. Though commercially successful in that location for a considerable period of years, the process required so vast an amount of cheap power as to prevent its general introduction.

This was the situation when Dr. Adolph Frank, of Charlottenburg, turned his attention to the problem. He first succeeded in producing barium cyanid by passing nitrogen over hot barium carbide. When, however, he substituted calcium carbide for that of barium in the process he found, to his surprise, that the product was not calcium cyanid but a new and wholly different product, namely, calcium cyanamid. When heated with high-pressure steam it yields ammonia, and ammonia is similarly, though slowly, evolved when the cyanamid is in contact with moist soil.

Concerning these discoveries Dr. Robert Kennedy Duncan wrote in 1907, "We see that the disaster of which the world actually stood in imminent deadly peril has been averted, and that if every pound of salt-peter in the mines of Chile were suddenly to dissolve into its elements, the human race would still be able to guard itself against the unhumanity of nature."

In that same year the American cyanamid patents were bought by Mr. Frank S. Washburn who organized the American Cyanamid Company, which has since made hundreds of thousands of tons of cyanamid for fertilizer and ammonia.

We have thus in the history of calcium carbide and its related products, a few of which only have I mentioned, another instance of the earning power of chemistry and another striking example of the way in which a chemical industry grows.

It is evident from certain definite trends that chemical industry is developing a new technology, in which the chemical engineer is destined to play an increasingly important part. Conspicuous among these trends is that toward synthetic processes involving the use of extremely high pressures, and in which the materials concerned are often at the same time subjected to high temperatures. For example, in the recent processes for the fixation of atmospheric nitrogen in the form of ammonia, the nitrogen and hydrogen are delivered to the catalyst at pressures of 1500 to 15,000 pounds and at temperatures which may exceed 900°F.

Urea, valuable as a fertilizer and as a constituent of new plastics, is now made synthetically by combining ammonia and carbon dioxide under 1500 pounds pressure at about 300°F.

The Bergius process for the liquefaction of coal involves the handling of hydrogen at 2200 to 3000 pounds pressure and at temperatures which may exceed 930°F.

Higher and higher pressures are being employed in the production of gasoline by the cracking of petroleum. In the Cross process, for instance, by which about 60,000,000 barrels of oil are annually treated for this purpose, pressures may reach 1000 pounds while the oil undergoing treatment is at 900°F.

In the development of these and other processes in the laboratory pressures as high as 15,000 pounds are not uncommon, and in some instances they may reach 22,500 pounds.

Obviously, such extreme demands upon equipment involve great difficulties in making gas-tight systems and in valve design. Further difficulties are introduced when the materials concerned are of a corrosive nature. It is greatly to the credit of chemical engineers that they have so successfully solved these problems that many processes are already in commercial and profitable operation at these high pressures.

High pressures are similarly employed at the other end of the thermometric scale in the numerous processes now concerned with the liquefaction of gases. Liquid chlorine, which nearly cost Faraday an eye, is now shipped about the country in tank cars. Propane and butane, recovered from natural gas, and sulfurous acid gas are similarly shipped in liquid form. Much higher pressures, and temperatures approaching the absolute zero, are employed in the liquefaction of air and the separation therefrom of nitrogen for the synthetic ammonia processes, argon for incandescent lamps, and neon for the flaming tubes which are bringing a new and lurid radiance to advertising.

The same procedure holds forth much promise of cheap oxygen in the near future. The high temperatures obtainable through its use with fuel should permit oxygen to invade, within a few years, the electric-furnace field, thus extending high-temperature metallurgy and facilitating the production on the large scale of super-refractories, high fusion-point glasses, and even of fused quartz.

Since a water-gas set can be operated continuously with a mixture of steam and oxygen, cheap oxygen should introduce such economies in gas manufacture as will result in the rapid broadening of the field of gas utilization both in house heating and in small industrial furnaces and boilers. Just as the electric central station has eliminated many small power plants so the gas central station will probably more and more replace, with high efficiency gas boilers, small coal-fired boilers now operating at efficiencies of 60% or less.

Many other developments in the processing of fuels are impending, but their consideration would so expand this lecture as to leave you in the frame of mind of that editor of *The Atlantic Monthly*, who inquired of Henry James, when his "Portrait of a Lady" went to inordinate length, "Is this a portrait or a panorama?" I may, however, say, in passing, that many of these developments have for their objective the production of smokeless fuel and new values in by-products by the low-temperature carbonization of bituminous coal.

Another important trend is that toward the utilization of petroleum and natural gas as raw materials for chemical syntheses. Already have processes been developed for the production of various alcohols and solvent acetates from the gases formed in cracking petroleum. Many fatty acids have been made from the same material by methods of oxidation, which also yield numerous other organic products. It seems altogether probable that we shall presently have a chemical industry based on petroleum and comparable in its importance to that developed from coal tar.

Of somewhat similar character and significance are the new synthetic processes for the preparation from water gas of methanol and other alcohols on the one hand, and of the whole series of paraffin hydrocarbons from methane to solid paraffin on the other. The ultimate effect of these and similar processes may be to involve the gas companies in a new chemical industry.

The intimate contacts and vast surface exposure induced by high-speed stirring have been found to facilitate many chemical reactions to a remarkable degree. The experimental results obtained with stirrers running at 30,000 r. p. m. seem to foreshadow new types of processes and equipment.

Still another definite trend is toward processes employing ultraviolet light and other forms of radiation to promote reactions not otherwise

easily induced. We are just beginning to appreciate the profound effect of radiant energy in promoting chemical change, and the new Coolidge tube, which operates at 900,000 volts, should greatly extend our knowledge in this promising field.

There is also a marked tendency toward the broader utilization of biochemical processes in the production of organic compounds. A notable example of this is the very successful application of bacterial action in the fermentation of corn to butyl alcohol and acetone. Numerous other products, together with acetone, have been derived through fermentation of the giant kelps of the Pacific Coast.

By means of special ferments and control glycerine is now cheaply derived from sugar. Other types of fermentation have been made to yield substantial proportions of fats.

The discovery that ordinary yeast is rich in vitamins has tended to develop its use as a medicinal food. Yeast is, however, also so rich in proteins and other constituents of high dietetic value that much present consideration is being given to it as an ultimate source of staple food products.

Some of you, who can supplement your technical training with an endowment of business ability, will presumably at some time in your careers be impelled to launch a chemical enterprise. With that possibility before you, you cannot begin too early to establish sound financial contacts and make a reputation which inspires confidence in your technical and business ability and in the character behind them. You must bear in mind that the making of a reputation is not so much a matter of spectacular achievement as it is the slow accretion of a multitude of minor responses in your daily contacts. Many of you have already made such reputation with your fellows as will react favorably or unfavorably upon your fortunes twenty years from now.

One of our most successful chemists, Dr. Leo H. Baekeland, the distinguished inventor of velox paper and of that remarkable plastic, Bakelite, has this advice to give:

"Pick your business associates with more regard to exceptional personal qualifications and business experience than to the money they may subscribe, but remember that starting a chemical enterprise with insufficient capital is one of the most effective ways of ensuring failure and that every chemical enterprise should have at least one competent chemist on its board of directors."

Dr. M. C. Whitaker, who received the Perkin Medal for his notable achievements in organizing chemical industries, similarly stressed the importance of the human factor in such enterprises when he attributed his success to the care he has exercised "in the selection and training of his bosses." In further definition of his policy he said: "We always see to

it that officers and directors understand what we are trying to do and how we are trying to do it. We discuss our projects and policies and program with them. We do not even deny them the privilege of sharing our disappointments and understanding our failures."

I have given you some examples of the earning power of successful chemical enterprises and have endeavored to indicate the direction in which development seems likely to proceed. I should now point out to you some of the many factors that may involve a chemical industry in failure.

Not only must ample capital be assured, but it must be what John E. Teeple has defined as "educated money," "money that is accustomed to distinguish between a day dream and a real vision that can be logically supported, money that is content to build slowly and constructively, looking for its return five or ten years ahead."

Money of this sort cannot, ordinarily, in this country, be obtained from bankers, since they aim to keep their resources liquid and to make their profits on its frequent turnover.

Make sure your project is not too far ahead of the times, for many otherwise meritorious enterprises have failed from this cause only to be revived by others years afterward and brought to a successful issue.

Be chary of engaging in a secondary enterprise which depends upon a primary one over which you have no control. Otherwise your supplies of raw material or the market for your product may be in jeopardy.

Many have lost great opportunities in chemical industry simply through lack of staying power. As Mr. Aldred said in his introduction to this course, "Every enterprise which has gone through to the full measure of success has been at one time *almost* a failure." Chemical enterprises sometimes require the bulldog tenacity of Count de Chardonnet, whose first three companies for the manufacture of artificial silk were failures, whereas the stock of the fourth went to 2280.

The same chemical process may, in different hands, give very different yields, and for this reason the success or failure of a specific enterprise is often determined by the technical skill with which the process is operated. The margin between good and bad practice is far greater here than that commonly found in the fabricating industries.

The development of new processes which is constantly going on may, according to conditions, be either a menace to the chemical manufacturer by the sudden creation of new competition which he cannot meet, or such development may bring him an unearned increment of profit by furnishing a new market for his product.

The obvious advantage of having the new process originate within his own organization and the vital importance of high yields in all his opera-

tions cause the progressive chemical manufacturer to make liberal appropriations for research.

Without research no chemical industry is safe. As C. F. Kettering puts it, "If you have no problems in your business, if you are perfectly satisfied with your product, your processes and your costs in all respects, if you have no trouble from competition or other sources of worry, and are sure you are not going to have any for ten years to come, then you *may* not need research."

Chemistry, through research, has drawn healing and beauty from coal tar; ensured our food supply by producing nitrates and ammonia from the air; provided new metals and endowed with properties of greater usefulness the metals previously known. In these and countless other ways it has contributed to our well-being, opened the horizon of our minds, and enriched and prolonged our lives. It has developed great industries which are peculiarly its own, but chemistry pervades all industry. It is conferring upon us daily new means and agencies for the better control of matter, which offer to you young men, just entering on your careers, opportunity to participate in those greater triumphs which are to come. Chemistry is a creative science, and the first chapter of its Book of Genesis is not yet written.

Danish Scientists Find Vitamin Virus. The formation of the anti-neuritic vitamin B somewhere in the digestive systems of laboratory rats that have previously been deprived of this necessary factor is an unexpected development in vitamin research recently reported from Copenhagen.

Dr. L. S. Fridericia and a group of workers at the university department of hygiene at Copenhagen found in the course of working with rats deprived of vitamin B that one rat did not die as usually happens with animals on this deficient diet. While making observations on this unique specimen it was discovered that other rats weakened by lack of vitamin B recovered if they were fed on secretions from the immune rat that had gotten well spontaneously.

After large numbers of experiments, Dr. Fridericia came to the conclusion that the apparently spontaneous cure is infectious, just as diseases are infectious. He believes that the rats are cured by being infected with a virus which forms vitamin B in the rat's alimentary canal. In this way, the rat is really obtaining a supply of vitamin B, although it is completely absent from its diet. From the evidence that large numbers of undigested starch grains are found in the secretions of the cured animals it is thought that the action of the virus is also linked up in some way with the digestion of starches.

Independent work by Miss Margaret Roscoe at the Lister Institute and by Dr. R. Adam Dutcher at State College, Pennsylvania, have confirmed some of the remarkable results of the Danish investigators. While the significance and application of these various experiments is not yet clear to scientists, they are so contradictory to all that has yet been learned about vitamins that it is felt that they will have an important bearing on future developments in vitamin research.—*Science Service*

DR. EDGAR FAHS SMITH*

C. A. BROWNE, BUREAU OF CHEMISTRY AND SOILS, WASHINGTON, D. C.

The many readers of CHEMICAL EDUCATION who had come to know Dr. Edgar F. Smith, either personally or through his numerous contributions to the pages of THIS JOURNAL, were greatly shocked to learn of his death on May 3, 1928, shortly after 8.00 o'clock in the evening, at the University of Pennsylvania Hospital, Philadelphia. Dr. Smith had attended the meeting of the American Chemical Society at St. Louis only two weeks before, where in the best of spirits he renewed associations with his many friends and gave an address before the Historical Division upon "Some Experiences as a Teacher of the History of Chemistry." Shortly after his return to Philadelphia a cold which he had contracted began to show alarming symptoms. His illness developed into pneumonia, from which he had suffered a serious attack two years before, and, notwithstanding all the aid which wifely devotion and medical skill could offer, his system was unable to withstand a second onset of this disease. The funeral services were held on Monday forenoon, May 7th, at Holy Trinity Church, Philadelphia, and among the large number in attendance were representatives of the American Chemical Society, the American Philosophical Society, the History of Science Society and the various other organizations of which the deceased chemist was a member.

Edgar Fahs Smith was born on May 23, 1854, in York, Pennsylvania, where his ancestors of English and German stock had settled several generations before. The greater part of his life work as student, teacher, and investigator was spent in Pennsylvania within one hundred miles of his birthplace and the intense attachment which he bore to the traditions of this historic region was reflected in many of his writings. His early education was obtained at the York County Academy, from which he passed in 1872 to the Junior class of Pennsylvania College at Gettysburg where he received the degree of Bachelor of Science in 1874. His father, who was a merchant, desired his son to enter business, but the boy's first ambitions were in the direction of medicine, the same career in which his younger brother, the late Dr. Allen John Smith (1863–1926), was later to win such great distinction.

In his work at Pennsylvania College the elder brother showed a marked inclination toward natural science, more especially chemistry and mineralogy. His professor of chemistry was the late Dr. Samuel P. Sadtler

* It is understood that a review of Dr. Smith's contributions to chemical science will appear shortly in the *Journal of the American Chemical Society*. The present sketch will, therefore, be limited to a consideration of some of his relations to those cultural aspects of chemistry with which the JOURNAL OF CHEMICAL EDUCATION is chiefly concerned.

(1847–1923) who, noting the boy's interest in chemistry, encouraged him to visit Germany and continue his studies there. The University of Göttingen, where the great Wöhler was still active, was at that time the Mecca of Americans who wished to complete their chemical education abroad and it was there that young Smith spent the next two years, studying chemistry under Wöhler and Hübner and mineralogy under Von Walthershausen. Dr. Smith was always fond, as at the recent St. Louis meeting, of relating incidents connected with his student life at Göttingen and with the genial Wöhler under whom he took his doctor of philosophy degree in 1876. As is customary at German Universities with graduates who have lived to celebrate the fiftieth anniversary of their promotion to the doctorate, this degree was again conferred in 1926 by the University of Göttingen. The transmission of the diploma formed a pleasing part of the recent Golden Jubilee exercises of the American Chemical Society at Philadelphia on September 7, 1926, at the same time when the Priestley Medal was also awarded to Dr. Smith for his distinguished services in chemistry.

Upon his return to the United States in 1876 Dr. Smith accepted an appointment as assistant in analytical chemistry to Professor F. A. Genth of the Towne Scientific School of the University of Pennsylvania, where he remained for the next five years. His relations during this period with Dr. Genth and with Dr. J. Lawrence Smith, who was a frequent visitor to Genth's laboratory, are charmingly told in Dr. Smith's review of a "Half-Century of Mineral Chemistry in America" in the Golden Jubilee Number of the *Journal of the American Chemical Society*.

In 1881 Dr. Smith accepted an appointment to the Asa Packer professorship of chemistry at Muhlenberg College, Allentown, Pa., which he resigned after two years in order to become professor of chemistry at Wittenberg College, Springfield, Ohio, where he remained from 1883 to 1888. It was during this period that he published his translations of Richter's Inorganic and Organic Chemistries, of which the numerous editions served for several decades as textbooks for many thousands of American students.

In 1888 Dr. Smith returned to the University of Pennsylvania to accept the professorship of analytical chemistry which had been vacated by the retirement of Dr. Genth. This change brought him again into association with his former teacher, Dr. S. P. Sadtler, who in 1874 had left Pennsylvania College to become professor of organic and industrial chemistry at the University of Pennsylvania. In 1892 upon the resignation of Dr. Sadtler the University's department of chemistry was reorganized with Dr. Smith at its head.

The period following Dr. Smith's return to the University of Pennsylvania was one of great scientific productivity in which he conducted with his pupils a vast number of investigations upon methods of electrochemical

analysis, atomic weight determinations, compounds of the rarer metals and complex salts of various inorganic acids. He was a pioneer in the field of "Electrochemical Analysis" and his book upon this subject which ran into six editions, was translated into numerous foreign languages. His work upon molybdenum attracted wide attention and his researches upon tungsten and its compounds undoubtedly paved the way for the present extensive use of this element in the arts and sciences.

Dr. Smith's abilities as an organizer and educator were quickly recognized. In 1898 he was appointed vice-provost of the University, upon

the resignation of Dr. Fullerton, although he still retained his professorship of chemistry. Upon the resignation of Dr. C. C. Harrison in 1911, Dr. Smith was appointed Provost of the University, an office which he held until 1920, when he resigned both as Provost and Blanchard professor of chemistry. Under Dr. Smith's administration the University of Pennsylvania entered upon a period of great prosperity; not only were millions of dollars raised to increase the material equipment of the institution but there was also a great quickening in the intellectual and spiritual life of the University. Educational requirements were raised, the salaries of professors were increased, and there was a general reorganization of the various schools of instruction. It has been truly said of him that he gave the University a soul.

Following his retirement in 1920 from active administrative duties Dr. Smith found greater leisure, as Emeritus Professor of Chemistry, for promoting an interest in the humanistic aspects of chemistry, which he felt were being neglected in the predominating industrial stress of American civilization. The cultural side of chemistry had always appealed to him and at an early period of his teaching he began to give lectures upon the history of this science. His great ability as a teacher and the stimulating influence of his genial personality caused his pupils to become interested, even in the more abstruse phases of the history of chemistry, with the result that the dullest mind could absorb something of value and importance.

While Dr. Smith's interests in the history of chemistry were general, the influence of local attachments induced him to limit his own investigations in this field to the developments of chemistry in America and more particularly within his native state. He disclaimed the title of historian and stated that the development of theories, the founding of industries, and the fixing of dates did not interest him so much as the personalities of the chemists who had promoted the growth of the science. A piece of historic apparatus or an autographed letter attracted him more for the fact that upon this piece of glass or upon that sheet of paper the living hand of Priestley or of Lavoisier once rested rather than for any novel principle of construction or statement of new theories that was involved. Dr. Smith was a great humanist and regarded his fellowmen as of more consequence than their works.

In his historico-chemical studies Dr. Smith became what every true student of the history of chemistry must become, an enthusiastic collector. His office in the Harrison Chemical Laboratory was without doubt the most attractive room that was ever occupied by an American professor of chemistry. Its antique furniture and other adornments were a perfect expression of his own ideals. The walls were hung with hundreds of portraits of chemists and the cases and shelves were filled with a vast assortment of prints, autographed letters, medallions, rare books, and other mementos. It was one of the most extensive collections of the kind ever assembled and a chief enjoyment of Dr. Smith in his later years was the showing to sympathetic friends of interesting items from his treasure-house. His last published volume upon "Old Chemistries," consisting of random observations upon some fifty volumes selected from his shelves, will always serve as an example of the inspiring conversations with which he entertained his visitors. Dr. Smith's accumulation of Priestleyana, the largest of its kind, containing Priestley's balance, the original manuscript of Priestley's "Memoirs" and many other items, was deposited by him in 1926 in the Priestley Museum at Northumberland, Pennsylvania.

The fate of the magnificent collection, which had been assembled with

so much care, was a cause of some anxiety to its owner. He dreaded to think of this valuable historical material being scattered, or buried away in the dark corners of some library or museum. No more fitting tribute could be paid to Dr. Smith than the preservation of his office and its priceless contents as a permanent memorial. Apart from the sentimental reasons, which appeal especially to the thousands who loved Dr. Smith and recall the pleasant hours spent with him in that room, a memorial of this character, if made available to the use of students of chemistry and of the history of science, would be a most valuable research and educational asset. It would also serve as a reminder to future generations that there once lived in this industrial age a saintly man who held that chemistry had other messages than those of commercial values—"messages in history, in philosophy, in economics, in social relations, in art, in international relations, in literature and in a wide and extensive culture," to quote from the concluding sentence of "Old Chemistries."

In furtherance of the cultural aims of chemistry Dr. Smith was influential in establishing during his presidency of the American Chemical Society in 1921 and 1922, the two divisions of "Chemical Education" and "Historical Chemistry," of both of which he was the first chairman. His influence in these fields was far-reaching and he had the satisfaction before passing away of seeing the two movements, which he so zealously sponsored, firmly established among many faithful followers upon a basis of continuous growth.

Dr. Smith was a most prolific writer. He was the author or translator of a dozen or more textbooks and laboratory manuals of chemistry. In the field of historical chemistry he published his well-known books upon "Chemistry in America" (1914), "Robert Hare—An American Chemist" (1917), "James Woodhouse" (1918), "Chemistry in Old Philadelphia" (1918), "James Cutbush" (1919), "Priestley in America" (1920) and "Old Chemistries" (1927). He published also some twenty historical monographs and brochures upon the lives of J. C. Booth, Franklin Bache, S. L. Mitchill, M. Carey Lea, John Griscom, J. B. Rogers, and other American chemists, as well as numerous addresses relating to the history of chemistry and to chemical education. Dr. Smith's personality was reflected in all that he wrote. He was a master of the living phrase and his sketches of American chemists are breathing likenesses of the men whom he portrayed. At the time of his death he was engaged upon writing the life of Dr. C. M. Wetherill, the first chemist of the U. S. Department of Agriculture. It is hoped that this last contribution from the pen of Dr. Smith may soon be published in the JOURNAL OF CHEMICAL EDUCATION.

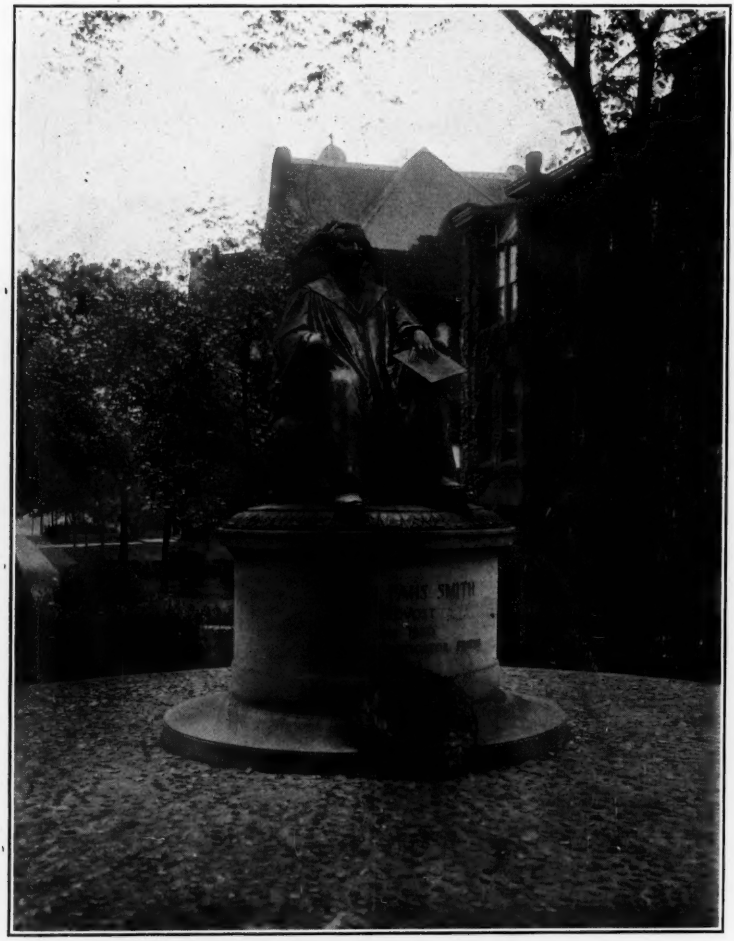
Dr. Smith cared little for marks of distinction although few scientists have been awarded so great a number of degrees, medals, or honorary appointments. Only a few of the more important honors which he re-

ceived can be mentioned. He was President of the American Philosophical Society from 1902 to 1906, was thrice elected President of the American Chemical Society, and at the time of his death was President of the History of Science Society. He was a member of the National Academy of Sciences and an Officer of the Legion of Honor of France. He occupied the highest positions in every organization with which he was

A CORNER OF DR. SMITH'S OFFICE, WHICH IT IS HOPED MAY BE PRESERVED AS A SHRINE OF AMERICAN CHEMISTRY

connected, whether scientific, educational, historical, or fraternal. He also responded to the public call whether in the service of country, city, or state. Among the many varied offices which he filled may be mentioned president of the Wistar Institute of Philadelphia, trustee of the Carnegie Foundation, and memberships upon the Jury of Awards of the Chicago Exposition, the U. S. Assay Commission, the Pennsylvania State Council of Education, and the Commission for Revising the Constitution of Pennsylvania. He

was appointed by President Harding to the Board of Technical Advisors in the Disarmament Conference. He was a member of the Electoral College of Pennsylvania in 1915, but always held aloof from political activities, declining even to consider a nomination to the highest office of his state.



THE EDGAR FAHS SMITH STATUE

The statue was the gift of John C. Bell, 1884 Law, University of Pennsylvania. Trustee of the University of Pennsylvania. Former Attorney-General of the State of Pennsylvania.

The inscription on the front of the statue is "Teacher—Investigator—Friend." On the back, "A tribute of affection from John C. Bell, Class 1884."

Finally, it may be said that Dr. Smith was in every sense of the word a philanthropist. He gave freely of his limited resources to every worthy cause and assisted many needy students to obtain an education. He might easily have amassed a fortune from the industrial utilization of his discoveries, but he chose rather to serve his fellowmen. The following note of appreciation in 1910 by Dr. J. H. Penniman, who afterwards succeeded him as Provost, is a rare tribute to Dr. Smith's wonderful uplifting influence.

"It is difficult to say in what respect Dr. Smith is really greatest, for his personal force exerted on men has made for righteousness in their lives, his tender love of his fellowmen has caused tears to well forth from fountains that, through sin and misery, had seemed dried up, and his gentle sympathy, deep and true, with the problems and temptations of men's lives have drawn to him hundreds who might otherwise have been discouraged and beaten by the realization of their own weakness and the inadequacy of merely human stength."

With the advancement of age Dr. Smith felt it necessary to discontinue many of the activities in which he was engaged, but his heart remained steadfast to the end in its love of the science to which he first pledged allegiance. Only lately he remarked that he must now let go of many things but that chemistry would be forsaken only with life itself.

The chemists of America were indeed most fortunate that they had as their friend so good and so great a man as Edgar Smith. Men with his combined qualities of wisdom, benevolence, magnanimity, and inspiring leadership come rarely among us. Upon the pedestal of his statue on the campus of the University, which he served as Provost, are inscribed the simple words "Teacher, Investigator, Friend." It was in acquiring friends that Edgar Smith won his greatest happiness and reward.

DELEGATES TO THE INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

At the annual meeting of the Division of Chemistry and Chemical Technology of the National Research Council, the following chemists were appointed as members of the official American delegation to the meeting of the International Union of Pure and Applied Chemistry, which is to be held at The Hague, July 18–24, 1928.

Ross A. Baker, Syracuse University; Wilder D. Bancroft, Cornell University; Edward Bartow, University of Iowa; John B. Ekeley, University of Colorado; W. H. Gesell, Lehn and Fink; F. G. Keyes, Massachusetts Institute of Technology; W. Lee Lewis, Institute of American Meat Packers; R. B. Moore, Purdue University; A. M. Patterson, Antioch College; C. L. Reese, E. I. du Pont de Nemours and Co.; L. H. Ryerson, University of Minnesota; Atherton Seidell, U. S. Public Health Service; W. T. Taggart, University of Pennsylvania; C. P. Smyth, Princeton University; R. E. Swain, Stanford University.

LIQUID AMMONIA AS A SOLVENT AND THE AMMONIA SYSTEM OF COMPOUNDS. I. LIQUID AMMONIA AS A SOLVENT

W. CONARD FERNELIUS, STANFORD UNIVERISTY, CALIFORNIA, AND WARREN C. JOHNSON, UNIVERSITY OF CHICAGO, CHICAGO, ILLINOIS

Introduction

During the past few years a considerable number of investigations have been carried out in which liquid ammonia has been used as a solvent. A great number of interesting results have been obtained from these investigations which have extended our knowledge concerning many chemical substances. By means of this solvent, reactions have been studied which do not lend themselves to investigation in water and at the same time a system of acids, bases, and salts, analogous to the water system, has been constructed. A study of the physical and chemical properties of liquid ammonia solutions has already appeared as an important factor in formulating our conceptions as to the nature of various substances.

In this series of articles an attempt is made to point out the more important results of the researches on liquid ammonia solutions carried out in this country during the past thirty years. These results concern primarily the investigations of Prof. E. C. Franklin and Prof. C. A. Kraus and their collaborators. It is hoped to show how these results may be applied to various phases of inorganic and organic chemistry.

It will not be possible to give an extensive presentation of the history of the subject, nor can complete references be cited. Only the more important historical developments and original articles will be included.

The Physical Properties of Liquid Ammonia

Numerous researches have been made upon liquid ammonia with a view toward determining its physical and chemical properties. In particular the intimate relationship which this solvent bears to water, the most universal of solvents, has been pointed out and used to explain a multitude of reactions. The resemblance of these two solvents has been admirably expressed in a paper by Franklin and Kraus.[1]

> Although it has long been recognized that many derivatives of water have their analogues in certain ammonia derivatives, still the intimate relation existing between the two liquids seems never to have been fully recognized.
>
> Water occupies an essentially unique position among the well-known solvents. Its physical properties such as its capacity as a general solvent for salts and its power of electrolytic dissociation, its low molecular elevation constant, its high boiling point, and its heat of fusion, heat of volatilization, critical temperature, specific heat, association constant, and dielectric constant with values so very much higher than the corresponding values for other substances, all tend to remove it far from other solvents and to place it in a class by itself.

[1] *Am. Chem. J.*, **21**, 8 (1899).

TABLE I

PROPERTIES OF AMMONIA AND WATER

	Liquid Ammonia	Water
Melting point	−77.7°	0°
Boiling point (760 mm.)	−33.35°	100°
Specific heat	1.13	1.0
Specific gravity at 20°	0.607	0.9982
Critical temperature	131°	365°
Critical pressure	112 atms.	195 atms.
Dielectric constant	22	81.7
Molal freezing-point constant	0.98	1.858
Molal boiling-point constant	0.34	0.52
Heat of vaporization (normal boiling point)	337 cal.	536 cal.
Heat of fusion	108 cal.	79.5 cal.
Specific conductivity	5×10^{-11} at −33°; 4×10^{-8} at 18°	

Of all known liquids, ammonia most closely approaches water in all those properties which give to water its conspicuous position among solvents. In its capacity as a general solvent for salts it is secondary to water, but superior to all other solvents. It closely approaches water in its power of dissociating electrolytes; some salts conduct electricity even better in ammonia solution than they do in water solution. It plays a part in many compounds analogous to that occupied by water in salts containing water of crystallization. Its heat of volatilization and probably its association constant are higher than those of any other liquid with the one exception of water. For a substance of such simple composition its critical temperature and critical pressure, and even its boiling point at atmospheric pressure, are remarkably high, as is still more conspicuously true of the corresponding constants in the case of water. Its specific heat is quite as great as that of water while its molecular elevation constant is lower than that of any other substance for which measurements have as yet been made.

Solubility Relationships of Liquid Ammonia

Ammonia differs from water in its inability to dissolve the sulfates and sulfites, the alkaline carbonates, phosphates, and oxalates, the hydroxides of the alkali and alkaline-earth metals, and the facility with which it dissolves many organic substances, in which latter respect it reminds one of alcohol rather than of water. The liquid does not exhibit a maximum density above the freezing point nor is the solid ammonia specifically lighter than the liquid at its freezing point, as is true of solid and liquid water.

Many of the solubility relationships of substances in liquid ammonia are extremely interesting and oftentimes completely at variance with the solubilities in water. Red mercuric iodide, HgI_2, dissolves very readily in ammonia to form a colorless solution from which it separates in the form of clear, colorless crystals containing two molecules of ammonia, $HgI_2 \cdot 2NH_3$. On exposure to the air, the latter compound effloresces and the original red mercuric iodide remains. The familiar dark blue copper nitrate pentammonate, $Cu(NO_3)_2 \cdot 5NH_3$, dissolves to give a deep blue solution. Potassium permanganate is very soluble, forming a solution of the same color as that in water, but it reacts after a short time with the solvent

to precipitate manganese dioxide and liberate gaseous nitrogen. Lead iodide forms a colorless solution from which the salt separates out with ammonia of crystallization. Sodium chloride separates out of ammonia solution at low temperatures in long needles containing five moles of ammonia. Barium chloride is very difficultly soluble but forms barium chloride octammonate, $BaCl_2.8NH_3$, with considerable increase in volume. The chlorides of magnesium, calcium, zinc, cadmium, manganese, cobalt, nickel, and lead form similar insoluble complexes. A few of the sulfides, such as ammonium sulfide, arsenious sulfide, and germanic sulfide, are readily soluble. Bariumnit rate and silver nitrate are very soluble, each separating out of solution with ammonia of crystallization on cooling to low temperatures. The solubilities of the silver halides is the inverse of that in water: silver chloride is slightly soluble, silver bromide is much more soluble than the chloride, while silver iodide is extremely soluble. The unusual solubility of these halides is doubtless due to the formation of a complex silver ion. Of all inorganic compounds the thiocyanates appear to be the most soluble. Ammonia is interesting in that it dissolves several of the elements. All of the alkali and alkaline-earth metals dissolve readily to give deep blue solutions.[2] Sulfur dissolves forming a peculiar dichroic solution, red by transmitted light and a dirty green by reflected light. Iodine and yellow phosphorus likewise dissolve, the latter slowly. Hexane is somewhat soluble in ammonia while benzene is very soluble. Organic halogen derivatives are distinctly soluble as are most nitrogen-containing substances. Dyes are usually more soluble in ammonia than in water. Fluorescein gives the same fluorescent solution in ammonia that it does in water. As has been mentioned before, the solubilities of organic compounds in liquid ammonia in general resemble those of alcohol more closely than those of water.

Electrical Conductivity of Ammonia Solutions

Not only is liquid ammonia an excellent solvent but many of its solutions are good conductors of electricity. The conductivities of liquid ammonia solutions have been extensively studied by Cady, Franklin, and Kraus. Such studies have shown that, although there are some extraordinary phenomena requiring special explanation, the conductivities of ammonia solutions are essentially similar to those of aqueous solutions and our familiar ideas of conduction and dissociation can be extended in their entirety to ammonia solutions. On dilution, the molecular conductivity of these solutions approaches a maximum value, just as do the familiar aqueous solutions, showing that at infinite dilution there is complete ionization in both solvents. It is perhaps significant that ammonia solutions of strong

[2] The solutions of these metals are very remarkable in their properties and will form the subject of a later paper in this series.

electrolytes conform more nearly to the law of mass-action at low concentrations than do similar water solutions. A rather remarkable fact, however, is that the ions travel faster in ammonia than in water. The cause of this phenomenon can be attributed to the low viscosity of liquid ammonia. Because ammonia is less viscous and is a weaker dissociating agent than water, dilute solutions in ammonia are better conductors than dilute aqueous solutions while water solutions excel when concentrated. It is extremely interesting that concentrated ammonia solutions of the alkali and alkaline-earth metals conduct the electric current without polarization and with a facility approaching metallic conduction.[2]

The piece of apparatus sketched in Figure 1 is used for showing; first, the high resistance of pure liquid ammonia and, second, the very striking effect on the conductance of the liquid produced by the introduction therein of a minute quantity of a salt solute.

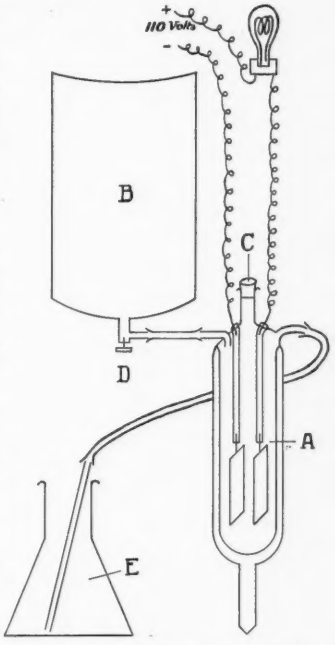


FIGURE 1

Liquid ammonia runs from the steel cylinder, *B*, of highly purified ammonia into the conductivity cell, *A*, when the valve, *D*, is partly opened. The gaseous ammonia formed by the volatilization of a portion of the liquid during the process of cooling is taken care of by absorption in water contained in flask, *E*. The two platinum electrodes, close together[3] and of large area, are connected in series with an incandescent lamp to the terminals of an ordinary 110-volt lighting circuit. The high resistance of the pure liquid is shown by the failure of the relatively high difference of potential to force the passage of sufficient current to heat the filament of the lamp even to the faintest luminosity. As a matter of fact the specific conductivity of pure liquid ammonia is far below that of the purest water.

When a minute quantity of a soluble salt (as little as 0.1 mg. of NH_4NO_3 dissolved in 20 cc. of solvent) is introduced into the cell through the tubulure, *C*—the stopper being removed momentarily for the purpose—the very dilute solution thus formed shows its conducting power by permitting sufficient current to pass to render the lamp filament distinctly

[3] Much closer than shown in the figure.

luminous. When a much larger quantity of solute is now added to the solution the resistance of the cell becomes so low as to constitute but a negligible element in the resistance of the circuit as shown by the fact that short-circuiting the cell produces a scarcely perceptible change in the luminosity of the lamp.

Metathetic Reactions in Liquid Ammonia

If salts in solution in ammonia are dissociated to an extent approximating the dissociation in aqueous solutions, then salts insoluble in ammonia should be precipitated rapidly and completely when ammonia solutions containing the ions necessary for the formation of such substances are brought together.[4]

Such action takes place in a number of cases. Thus in liquid ammonia, ammonium sulfide can be used to precipitate metallic sulfides just as it precipitates the heavy metals in water. In the former case, the sulfide precipitates of lead, copper, nickel, cobalt, etc., are not black. If one mixes aqueous solutions of silver nitrate and barium chloride, an immediate precipitation of insoluble silver chloride results. We account for the reaction by saying that the insolubility of the silver chloride in water causes the reaction to go to completion. In ammonia, however, silver chloride is more soluble than barium chloride so that the reverse of the above reaction takes place. Thus we might write this reaction,

$$2AgNO_3 + BaCl_2 \underset{NH_3}{\overset{H_2O}{\rightleftharpoons}} Ba(NO_3)_2 + 2AgCl$$

and indicate by the arrows the solvent being considered.

Everyone is familiar with the reaction of ammonia with the common acids to form ammonium salts. In liquid ammonia solution, however, these same ammonium salts behave as acids affecting indicators, dissolving metals with release of hydrogen, and, in general, showing all the properties which we customarily ascribe to the common acids. An ammonia solution of phenolphthalein in contact with solid sodium hydroxide is colored a deep purple color because the base is slightly soluble in liquid ammonia. If into this purple solution be poured a few drops of a solution of ammonium chloride, the color is immediately discharged. Now if the colorless solution is shaken for a time in order to dissolve a little more of the sodium hydroxide, the purple color returns. Thus the insoluble sodium hydroxide is dissolved by a solution of ammonium chloride,

$$NaOH + NH_4Cl = NH_3 + NaCl + H_2O$$

with the formation of water and sodium chloride. This is exactly the same reaction as the familiar neutralization of a base by an acid with which we are acquainted in water solution. Moreover, a solution of am-

[4] Franklin and Kraus, *Am. Chem. J.*, **21**, 1 (1899).

monium acetate in liquid ammonia attacks a strip of magnesium ribbon just as acetic acid does in water. The reactions are strictly comparable:

$$Mg + 2CH_3COONH_4 = (CH_3COO)_2Mg + H_2 + 2NH_3,$$

and

$$Mg + 2CH_3COOH = (CH_3COO)_2 Mg + H_2.$$

The behavior of the ammonium salts in liquid ammonia may be cited as evidence for the general solvation of dissociated substances. Indeed, there is evidence for believing that a solution of hydrochloric acid does not contain hydrogen and chloride ions but, instead, hydronium (OH_3^+) and chloride ions.[5] The hydrogen ion in ammonia is accordingly largely associated with the solvent to produce the ammonium ion, NH_4^+.

In our thinking about liquid ammonia, we must be careful to distinguish the pure liquid from the familiar aqueous solution of ammonia. Liquid ammonia is not an alkaline substance like its water solution but is an indifferent solvent as is water and like the latter is a perfectly neutral substance. Ammonia differs from water, though, in that the pure liquid is dissociated to a lesser degree than is water. Whereas the specific conductivity of pure water at 18° is 4×10^{-8} Kohlrausch units, that of pure ammonia is certainly not above 5×10^{-11} units or less than one one-thousandth that of water. Hence there are fewer of the ions, H^+ and NH_2^-, present in ammonia than there are of H^+ and OH^- in water. As a consequence, the ability of ammonia (*ammonolysis*) to reverse the neutralization reactions by which salts of weak acids or weak bases are formed is much weaker than the similar power (*hydrolysis*) of water.

To illustrate, if one attempts to obtain aluminum cyanide in water solution by the reaction of a solution of a cyanide with a solution of an aluminum salt, one obtains instead a precipitate of aluminum hydroxide. It is customary to say that the aluminum cyanide first formed has been entirely hydrolyzed to the weak base, aluminum hydroxide, and the weak acid, hydrogen cyanide, thus:

$$Al(CN)_3 + 3H_2O = Al(OH)_3 + 3HCN.$$

In liquid ammonia, on the other hand, no such reaction takes place and aluminum cyanide can be prepared with ease.[6] Ammonia thus comes to play an important rôle in the preparation of compounds which are incapable of existence in aqueous solution.

It is hoped that sufficient has been said above to convey a general idea as to the nature of liquid ammonia. Because of the unusual properties of

[5] In this connection it is interesting to note that anhydrous hydrogen chloride is not acidic but neutral in its properties.

[6] Bergstrom [*J. Am. Chem. Soc.*, **46**, 1559 (1924)] prepared this compound by the action of mercuric cyanide on aluminum in ammonia solution.

this substance, one can readily see that a great number of reactions may be investigated in liquid ammonia that are impossible to study in other solutions. The results of some of these investigations will be briefly discussed in the following articles of this series.

Practical Mining Rescue Kit Not Generally Used. Although the Chemical Warfare Service, during the World War, perfected a rescue kit providing protection against carbon monoxide and this protective device has been on the market since 1923, only 1 per cent of the 750,000 coal miners in the United States are equipped with the kit.

Recently the practical effectiveness of the kits was proved in an Alabama coal mine explosion when six out of eight men were rescued by using the kits. Two of the men who tried to make their way through without the kits were overcome by the gas and died.—*Science Service*

New Red Arc Light Shines through Fog. A brilliant red arc light that makes use of the rare atmospheric gas neon, and which can shine through thick fog, has been developed at the Research Laboratory of the General Electric Company here. The new lamp is the result of the work of Dr. Clifton G. Found in collaboration with J. D. Forney, of the Cooper-Hewitt Electric Company, and has just been demonstrated by them to engineers.

Airplane landing fields will probably be among the first to make use of the lamp, for by outlining the fields with them aviators flying above through fog will be enabled to make a safe landing. Such an occurrence as that of Commander Byrd on his flight to Paris, when he actually flew over Le Bourget, but could not see to land, would probably be prevented.

Docks in harbors may also be marked with the lamp. According to Dr. Found, the light has been tested for this use when one was recently placed on a pier in the Hudson River. "Observations from boats during fog," he says, "have shown that it was possible to pick up the red neon light before any of the other lights in the same vicinity were observed."

Earlier forms of neon tubes, which give the characteristic red neon light that is now so common in advertising signs, suffer from what is called the "cathode drop." This is the great difference in voltage between the electrode through which the electric current enters the tube, and the nearby gas. On account of it, also, tubes must be operated with a high voltage, and must be made quite long in order to be efficient. Another disagreeable effect is that the gas is made to gradually disappear.

The new tube of Dr. Found and Forney heats the cathode, or the electrode through which the current enters the tube, by means of an additional electric circuit. This causes it to give off the electrons which cause the neon gas to glow, but without the high voltages that are needed in the older tubes. By such means an extremely efficient source of brilliant red light can be obtained. Light of this color is best for penetrating fog.

Another possible use of the lamp is in photography, especially in colors. The mercury vapor lamp, which gives a characteristically violet-colored light, has often been used for ordinary photography, but the unnatural pallor which it causes is a disadvantage, especially where colors are concerned. By combining the neon light with the mercury vapor lamp, the former supplies the rays which are lacking in the latter, and the result, said Dr. Forney, is a good approximation to white light.—*Science Service*

BOERHAAVE'S ACCOUNT OF PARACELSUS AND VAN HELMONT*

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The history of chemistry which stands at the beginning of Boerhaave's treatise on that science is perhaps the oldest history of chemistry (of chemistry as distinct from alchemy) which we have. Boerhaave was born but a few years after the appearance of "The Sceptical Chymist." He was contemporary with Stahl but had no sympathy with the doctrine of phlogiston. He lived at a time when chemistry had recently become a well-recognized science in its own right. He actually talked with those who had talked with Van Helmont, and Van Helmont, who was born thirty-six years after the death of Paracelsus, thought so highly of the founder of chemical medicine that he visited his haunts to learn all that he could about him. When Boerhaave tells us about these two men, one of the greatest physicians and chemists of all time is telling us about his two most eminent predecessors.

After some years as professor of medicine and of botany at the University of Leiden, Boerhaave took on in 1718 the additional duties of the professorship of chemistry. He was well prepared for the task, for he had given private courses in chemistry for fourteen years previously. In his public course of lectures he apparently devoted the first lecture, or the first part of the first lecture, to a general account of the nature of chemistry and of the manner in which he proposed to treat the subject. The next several lectures were given over to the history of the science, to an account of the men who had made notable contributions, and to remarks, always keen and sometimes caustic, upon the books which had been written about it. After that the principles and the processes were taken up in due order.

Boerhaave's students evidently became impatient for a textbook, for they collated and edited their notes and published, in 1724, a pirated edition of his lectures under the title, "INSTITUTIONES ET EXPERIMENTA CHEMIAE," 2 vols. in 8vo. Although printed without his consent, the work carries the name of Boerhaave on its title page. It has nothing to indicate the publisher and gives Paris as the place of publication, but was probably printed at Leiden. And there is every reason to believe that it is a substantially accurate account of his lectures.[1] Another edition of this spurious textbook appears to have been published at Venice in 1726, and an English translation by Shaw and Chambers was issued under the title, "A NEW METHOD OF CHEMISTRY," etc., London, 1727.

* Paper read before the Section (now Division) of History of Chemistry at the 74th Meeting of the American Chemical Society at Detroit, Michigan, September 8, 1927.

[1] See "The Vicissitudes of Boerhaave's Textbook of Chemistry" by the present writer, *Isis*, **10**, 33 (1928).

Boerhaave disowned the spurious work, but blamed himself for what he considered its numerous faults. His friends urged him to write his treatise as he wished it to be, he undertook the ungrateful task, and finally published his authentic "ELEMENTA CHEMIAE," 2 vols. in 4to, Leiden, 1732. In order that readers might be sure that the work was really his own, he signed his name on the reverse of the title page of every copy of the first edition. It was enormously successful, and went through nearly thirty editions in Latin, English, German, and French. In English, Strother's abridgment appeared in 1733 and 1737, Dallowe's translation in 1735, and Shaw's translation in 1741 and 1753.

Peter Shaw's translation of the "ELEMENTA CHEMIAE" was published as the second and third edition of the "NEW METHOD OF CHEMISTRY" but is an entirely different work from the first edition of the same title, for that is a translation by Shaw and Chambers of the spurious "INSTITUTIONES ET EXPERIMENTA CHEMIAE.[2] In the present paper I quote the first edition for an English version of what Boerhaave said in his lectures and the later editions for an English version of what he wrote in the well-considered "ELEMENTA CHEMIAE."

Both in the lectures and in the later book Boerhaave's account of Paracelsus and Van Helmont is entertaining and well documented. That of the lectures is less formal, and it contains more of an anecdotal and personal nature. It shows a practitioner of medicine, conscious of the follies and foibles of his art, interested in Van Helmont's success with his patients and in the efforts of Paracelsus to collect his fees. It is easy to imagine the medical students who listened to the lectures on chemistry, building up in their minds dramatic and very human pictures of the great men, pictures instantly to be recalled in all their clearness when the professor later in the course should make mention of the chemical discoveries or observations which they had made.

Paracelsus comes next on the stage; a great, anomalous, unaccountable fellow; whose history will have the air of a paradox. He reform'd and alter'd the face of medicine, and turn'd it altogether into the vein of chemistry; being the first of all mankind, who, of a profess'd chemist, was made a public professor of medicine in an university. Never did any person bear such different, inconsistent characters as the author we are now about to treat of: amid so much diversity, it will require no small degree of attention and address, to keep the truth in view, and pursue it without deviating into any of the tracks of fable and fiction. To hear the generality of chemists talk, he was nothing less than a God; nay, 'tis a tradition, which I find several people believe, that he is not dead, but still lives in his tomb; whither he retired, weary of the vices and follies of mankind. And yet others represent him as one of the most vile, flagitious, and worthless of the race of men.

[2] The second and third editions of the "NEW METHOD OF CHEMISTRY" contain, as footnotes, many passages quoted from the first (translation of the spurious) edition, and are therefore more valuable and entertaining than Dallowe's translation.

To ascertain somewhat of the character of this memorable person, we have consulted all the writers on both sides the question; and will give you his story, not as 'tis drawn by his profess'd Devotees, the *Paracelsists;* nor yet from those, who determinately vilify him at all adventures, as *Erastus, Theophilus, &c.* But, principally, as deliver'd by *J. Oporinus, Greek* professor in the same university with *Paracelsus;* by *J. Crato a Krafthen,* an illustrious physician of that time, who conversed with *Paracelsus,* and whose writings have all the marks of candour and exactness; and by *Van Helmont* who travel'd into *Germany,* on purpose to enquire into the matter, and satisfy himself of the truth of the stories related of our philosopher: tho' as to this last author, we shall be a little on our guard; as he appears strongly inclined in favour of his master, and has publickly declared *Paracelsus* the *prince of physicians, and philosophers by fire.*[3]

Aureolus, Philippus, Paracelsus, Theophrastus, Bombast de Hohenheim, was the son of *Wilhelmus Hohenheim,* a learned man, and licentiate in physic; tho' a slender practitioner, but possessed of a noble library; being himself the natural son of a master of the *Teutonic* order. He was born in the year 1493, at a villiage of *Swisserland* called *Einsideln,* which signifies a wilderness or desart, about two *German* miles from *Zurich;* whence he got the appellation of *Eremita,* or hermit, which *Erasmus* gives him in a letter.

At three years of age he is said to have been mutilated, and made an eunuch by a sow. Accordingly we always find him a bitter enemy of the women; tho' his picture, as taken from the life, represents him with a beard. He was instructed by his father in physic and surgery, wherein he made great proficiency; but as he grew toward riper years he was captivated with the study of alchemy, which occasion'd his father to commit him to the care of *Trithemius* abbot of *Spanheim;* a man of great renown in those days, from whom having learned many secrets, he removed to *Sigismund Fuggerus* of *Schwatz,* a famous *German* chemist, who at that time, partly by his own industry, and partly by a multitude of servants and operators, retained for the purpose, made daily improvements in the art. And here he assures us he learnt spagiric operations effectually, after which he applied himself to all the most eminent masters in the alchemical philosophy; who concealed nothing from him, and from whom, as he himself relates, he learnt his secrets.

But not resting here, he undertook a journey to all the universities of *Germany, Italy, France* and *Spain,* in order to learn physic; after which he visited *Prussia, Lithuania, Poland, Walachia, Transylvania, Croatia, Portugal, Illyria,* and the other countries of *Europe,* where he applied himself indifferently to physicians, barbers, old women, conjurers, and chemists both good and bad; from all which he gladly pick'd up any thing that might be useful; and thus enlarged his stock of sure and approved remedies. . . . . .

In the twentieth year of his age, making a visit to the mines in *Germany,* he travelled on to *Russia,* where being taken prisoner on the frontiers, by the *Tartars,* he was carried before the *Cham,* and afterwards sent, with that prince's son, on an embassy to *Constantinople;* where in his 28th year, he tells us, he was let into the secret of the *philosopher's stone.* He was also frequently retained as chirurgeon and physician in armies, battles and sieges.[4]

At his return to his native country, he assumed the title of *utriusque medicinae doctor,* or doctor both of internal, and external medicine or chirurgery; and grew famous in both; performing things far beyond what the common practice of that time could pretend to.[5]

He set a high value on *Hippocrates* and the ancient physicians, but despised the scholastic doctors, and above all the *Arabs.* He made great use of remedies prepared of

[3] Shaw and Chambers, **1727,** Vol. I, pages 22, 23.

[4] Shaw, **1753,** Vol. I, pages 37, 38.

[5] Shaw and Chambers, **1727,** Vol. I, page 24.

mercury and *opium*, wherewith he cured the leprosy, venereal disease, itch, slight dropsies, and other infirmities, which to the physicians of those times (who were ignorant of *mercury*, and afraid of *opium*, as cold in the fourth degree) were utterly incurable.[6]

Paracelsus rapidly became celebrated—and daring in the use of his powerful medicines. His cure of Frobenius, the famous printer of Basil, made him acquainted with Erasmus and brought him to the favorable attention of the magistrates of that city who offered him the professorship of medicine and philosophy at the university. "The case of *Frobenius* appears to have been a violent pain in the heel, which upon *Paracelsus's* treatment, removed into his toes; so that the patient could never stir them afterwards, tho' he felt no pain, and in other respects grew well: but soon after died of an apoplexy."[7]

The art of printing was now a new thing; the taste for learning and arts was warm; and the magistracy of *Basil* were very industrious in procuring professors of reputation from all parts. They had already got *Desid. Erasmus*, professor of theology; and *J. Oporinus*, professor of the *Greek* tongue: and now, in 1527, Paracelsus was associated; in the 33d year of his age.[8]

After his reception, he publish'd a kind of advertisement, in the month of *June* 1527, where he expresses himself thus: "Being invited, with a large stipend, by the governours of *Basil*, I publickly interpret, for two hours, every day, my own books of practical and theoretical physic, natural philosophy and chirurgery; to the great advantage of my hearers."[9]

At his first lecture he procured a fire to be brought in a brazen vessel, into the middle of the school; where, after casting in sulphur and nitre, in a solemn manner, he burnt the writings of *Galen*, and *Avicenna:* alledging, that he had held a dispute with them in the gates of hell, and had fairly routed and overcome them. And hence he proclaimed, that the physicians should all follow him; and no longer call themselves *Galenists*, but *Paracelsists*.[10]

"Know, physicians," says he, "my cap has more learning in it than all your heads; my beard has more experience than whole academies of you: *Greeks, Latins, French, Italians;* I will be your king."[11]

While he was here professor, he read his books, *de Tartaro, de Gradibus*, and *de Compositionibus*, in public lectures; to which he added a *commentary* on the book *de Gradibus;* all these he afterwards printed at *Basil* for the use of his disciples; so that these must be allowed for genuine writings. About the same time he wrote *de Calculo;* which performance *Helmont* speaks of with great approbation.[12]

Here he procured many disciples, with whom he lived in great intimacy: three of these he maintained in diet and clothes, and instructed in several secrets; tho' they afterwards ungratefully deserted their master, and even wrote scandalous things of him administring with great indiscretion the medicines he had taught them, to the great; disadvantage of those who employ'd them. He also retain'd surgeons and barbers in

[6] Shaw, **1753,** Vol. I, page 38.

[7] Shaw, **1753,** Vol. I, page 38, translator's footnote.

[8] Shaw and Chambers, **1727,** Vol. I, pages 24, 25.

[9] Shaw, **1753,** Vol. I, page 38, translator's footnote.

[10] Shaw and Chambers, **1727,** Vol. I, page 25.

[11] Shaw and Chambers, **1727,** Vol. I, page 25, translator's footnote.

[12] Shaw and Chambers, **1727,** Vol. I, page 25.

his family; to whom he communicated useful secrets; but all of them soon after left him, and turn'd his enemies. His only faithful disciples were Dr. *Peter*, Dr. *Comelius*, Dr. *Andrew*, Dr. *Ursinus*, the Licentiate *Pangratius*, and Master *Raphael*, whom he speaks of with commendation.

During his two years'[13] residence here, he cured a noble canon of *Liechtenfels*, who had been given over by the physicians, of a violent pain at the stomach, with only three pills of his laudanum. The sick canon had promised him 100 *French* crowns for the cure; but finding it so easily effected, he refused to pay... Upon this *Paracelsus* cited him before a court of justice; where the judge, not considering so much the excellency of the art, as the quantity of labour and cost, decreed him a trifling gratification; with which *Paracelsus* was so exasperated, that loading them with reproaches of ignorance and injustice, he render'd himself in some measure guilty of treason; and thus thought best to quit the court, and make haste home. From whence by the advice of his friends, he privately withdrew out of the city.[14]

In his lectures Boerhaave tells how Paracelsus on this occasion pursued the court "with all the reproaches and railing his spleen could suggest," and adds that "a man thus provided, one would think, might make a shift in the world, without the philosopher's stone to help him out."

After this he continued rambling two years, thro' the neighboring parts of *Alsatia* accompanied by *Oporinus*, and in the course of a dissolute life wrought many extraordinary cures; as we find related by *Zwinger*, who lived at the same time at *Basil*, and often heard the account from *Oporinus* himself.

This *Oporinus*, who had been for some time his servant and *amanuensis*, was a person of much learning, well skilled in the *Greek* and *Latin* tongues; who, possessed with the vain expectation of attaining *Paracelsus's* secrets, left his own family and travelled about with him two whole years; without learning any one thing: till weary'd out he grew wise, and quitting *Paracelsus* return'd to *Basil*.

It happened, one evening, that *Paracelsus* was called to visit a countryman dangerously ill near *Colmar* in *Alsatia;* but being set in for a drinking-bout, with ordinary company, he deferred visiting the patient till next morning; when entering the house with a furious look, he ask'd if the sick person had taken any physic? as intending to administer some of his laudanum. The by-standers answered, he had taken nothing but the sacrament; as being at the point of death: at which *Paracelsus*, in a rage reply'd; if he has had recourse to another physician, he has no occasion for me and ran immediately out of doors. *Oporinus*, struck with this piece of impiety, bid *Paracelsus* the last adieu; fearing the barbarity of his otherwise lov'd master should some time fall on his own head.[15]

After this, he betook himself again to his itinerant life; spending his whole time in travelling, and drinking, and living altogether in taverns, and inns, continually flush'd, and loaden with liquor; and yet working many notable cures in his way. In this sordid manner did he pass four years, *viz.*, from the 43d to the 47th year of his life; when he died, as he lived, in an inn, at *Saltzburg*, at the sign of the white horse, on a bench, in the chimney-corner.....

Such was the life of *Paracelsus;* such was the immortal man, who, sick of life, retired into a corner of the world; and there supports himself with his own *Quintessentia*

[13] Paracelsus actually held the professorship at Basil for about one year. He left that city June 8, 1528.

[14] Shaw, **1753,** Vol. I, pages 38, 39.

[15] Shaw, **1753,** Vol. I, page 39.

Vitae. We now proceed to his books; and his pretensions to the grand *arcana* of alchemy.

In his lifetime, we have already observed, he only published three, or four books. But after his death, he grew prodigiously voluminous; scarce a year passing, but one book or another was published under his name; said to be found in some old wall, ceiling, or the like....

J. Oporinus, that excellent professor and printer above mention'd, who constantly attended *Paracelsus* for three years as his menial servant, in expectation of learning some of his secrets; who publish'd the works of *Vesalius;* and is supposed to have put them in that elegant language wherein they now appear: this *Oporinus*, in an epistle to *Monavius*, concerning the life of *Paracelsus*, professes himself surprized to find so many works of his master; for that in all the time he was with him, he never wrote a word himself, nor ever took pen in hand; but that as he spent all his time among porters and carmen, and was eternally drunk, he would sometimes come reeling home, and, brandishing his drawn sword, force *Oporinus* to write what he dictated. But this was but little. However, *Oporinus* used to wonder how such coherent words, and discourse, which might even become the wisest persons, should come from the mouth of a drunken man.

'Tis more than probable, then, that the bulk of the pieces published under his name, are not his; but that the other chemists, his followers, chose to usher in their performances under the sanction of his name.....And yet, beside the three books which he lectured in public, there are some others that seem to have good pretensions to be genuine: such is that *de Peste*, wrote for the sake of his hosts in the east, and about *Constantinople*, from whom he had receiv'd a deal of kindnesses, and whom he had then promised a remedy against the plague: that *de Mineralibus:* that *de vita longa:* and the *Archidoxa Medicinae*, which was published by *Bodensteyn*, while *Paracelsus* was living, or at least soon after his death.

This work is call'd *Archidoxa Medicinae*, as containing the principal rules and maxims of the art. Nine books hereof were published at first: and the author in the prolegomena to them speaks thus: *I intended to have published my ten books of* Archidoxa; *but finding mankind unworthy of such a treasure, as the tenth, I keep it close in my* occiput; *and resolve never to bring it thence, till you have all abiured* Aristotle, Avicenna, *and* Galen, *and have swore allegiance to* Paracelsus *alone.*

However, the book did at length get abroad; tho' by what means is not known: it is confessedly a glorious piece, and may be ranked among the principal productions in the way of chemistry, that have ever appear'd. Whether or no it be *Paracelsus's*, we will not affirm; but there is one thing speaks in its behalf, *viz.* its containing a great many things which have been since trump'd up for great *Nostrums;* and *Van Helmont's* lithonthriptic, and alcahest, are apparently taken hence...

Among the genuine writings of *Paracelsus*, are likewise reckon'd that *De ortu rerum naturalium*, *De transformatione rerum naturalium*, and *De vita rerum naturalium*. The rest are spurious, or very dubious at best; particularly the theological works...[16]

This, then, must be confess'd, that an arrogant, assuming air, infected all his writings, as well as his actions. It was familiar with him to promise mighty things with compleat assurance; upon slender, inadequate grounds. Could there be a greater instance of the man's foible in this respect, than his undertaking, by the mere use of his *Elixir Proprietatis* (a preparation of aloes, myrrh, and saffron) to prolong a man's life to the age of *Methusaleh;* and to deliberate with himself to what period he should protract his own? It argues his trusting to imagination more than experiment: for, as

[16] In the later "ELEMENTA CHEMIAE" Boerhaave gives a somewhat different list of the writings of Paracelsus, but he does not comment upon them as he does in his lectures.

he died a young man himself; 'tis certain he could not have experiments sufficient to warrant any such thing; nor did he speak of his knowledge, as a physician ought to do, but purely of his caprice.

We know not how it is, but the common body of chemists both of his and our times have complimented *Paracelsus* with the knowledge of the universal remedy; and he himself is at the head of the opinion; he swears by his own soul, and calls every God in heaven to witness, that with one single remedy prepared from metals, he was able to cure all diseases, be they stone, gout, cancer, or what they will: To hand down which opinion to posterity in the most solemn manner, it is engraven on his monument in the outer wall of the church at *Saltzburg*. But for all this assurance, a man may venture to withold his assent: His own history affords no great proofs of the thing; nor have we any competent testimonies of other writers. *Helmont*, who knew as much of *Paracelsus* as any man living, does not believe a word of it: That author is always commending him, but warns us not to trust to him; adding, that his writings are full of babble. *Crato*, in his epistle to *Monavius*, relates, that "upon the rumor of his great skill at the emperor's court, he was sent for to cure the great chancellor, then laid up of a gout. *Paracelsus* undertook the cure; and promis'd a very speedy recovery, on condition all the other physicians should be set aside. But after several weeks spent in vain, the patient rather going backwards every day; finding the most powerful of his remedies ineffectual, he slipt privately away, and cou'd never by any words or promises be brought to court again." *Borrichius*, who so warmly maintains him a master of all the arcana aim'd at by alchemists, would find somewhat to do, to give a reason for his failure in this instance: again, *Crato* adds, that being at a consultation with *Paracelsus*, *Crato* ask'd him why he cough'd, when he had so noble a remedy in his hands? to which *Paracelsus* answer'd, *I cou'd soon cure myself, were it not for this;* at the same time taking up a cup of wine.

But what effectually overthrows his pretensions to such a remedy, is his own dying at an immature age. When at *Saltzburg*, finding his days near a period, he sent for a notary to make his will; which is still preserv'd by the magistrates of the place. The same notary attests, that he found *Paracelsus* on his legs, and perfectly sensible; only very weak and languishing: If he had any notion of an universal remedy, this certainly was the time for it. As to what is objected from his epitaph, it will have no great weight; in these monumental inscriptions, we all know how little regard is had to historical truth.

The great fame and success of the man, which with some passes as an argument of his being possess'd of the secret; is easily accounted for from other principles. 'Tis certain he was acquainted with the use and virtues of opium... *Oporinus* relates that he made up a sort of little pills—which were nothing but *opium*. These he called by a barbarous sort of name, his *laudanum*, *q.d.* laudable medicine; he always carried them with him, and prescribed 'em in dyssenteries and all cases attended with intense pains, anxieties, deliriums, and obstinate wakings. But to be alone possess'd of the use of so extraordinary and noble a medicament as *opium*, were enough of itself to have render'd him sufficiently famous.

Another grand remedy which *Paracelsus* had to himself, was *Turbith Mineral*. This is first mention'd in his *Clein Spital Boeck*, or *Chirurgia minor;* where he gives us the preparation. "Take," says he, "mercury, mix it up with twice the quantity of oil of vitriol; precipitate, and wash it with water, and you will have a yellowish powder; distil it with spirit of wine, and administer it to the quantity of 8 grains; it will cure all the diseases above-mentioned." This is the very *Turbith* which the modern practitioners find of so much efficacy in the venereal, and almost all chronical and cutaneous diseases, where violent vomitories are required: Indeed the dose here mention'd is too large,

but he durst try any thing. *Oporinus* relates, that all the time he was with *Paracelsus*, he spent his sober hours in making his *Emplastrum opodeldoch*, and preparing *Turbith;* nor does he make mention of any other remedies.

By this time we have *data* enough to account for *Paracelsus's* mighty fame. 1, In that he was well skill'd in chirurgery, and practised it with great success. 2, That he understood the common practice of physic as well as his contemporaries. 3, That he was alone master of the powers, preparations, uses, &c. of metals. 4, That he had the use of *opium* to himself, and wrought wonderful cures thereby. And 5, That he was well acquainted with the virtues of mercury, in an age when no other person but *Carpus* knew any thing of the matter. These five concurring circumstances take in his whole merit; and were the matter of all his glory: the rest was empty smoke, and idle ostentation.

We have but little to say as to the philosopher's stone, which his followers put him in possession of; 'tis certain he was at first very poor, and grew at length immensely rich. *Oporinus* says, he has frequently wonder'd to see him one day without a farthing in his pocket, and the next day full of money; and that he never took any thing with him, when he went abroad. He adds, that he would often borrow money of his companions, the carmen and porters; and pay it again in 24 hours, with extravagant interest: and yet from what fund, no body knew. In the *theatrum alchemiae* he mentions a treasure hid under a certain tree, *quem tu Papilio, nec tu Carole unquam potestis aequare;* and from such grounds is supposed to have had the art of making gold. But, why have recourse to so violent a machine, when a lesser will do? "'Twas hard if such noble nostrums as he possess'd, would not subsist one man; when we find what considerable livelihoods are now got by every pitiful pretension to an *arcanum*."[17]

Van Helmont, whom Boerhaave calls "the greatest and most experienced of all the chemists that have yet appear'd" completed the work which Paracelsus had begun and wrought such a change in the art of medicine "that nothing at length could go down in *physic*, but what was thoroughly *chemical*." In order to get reliable information about him, Boerhaave "made industrious inquiry about *Brussels*, *Wilword*, and *Bois le duc*, the places where he spent the greatest part of his life," and "got intelligence which may guide us in forming a judgment of him."

John Baptist Van Helmont, was born of a noble family, at *Brussels*, in the year 1577, *viz.* 36 years after the death of *Paracelsus*. He lost his father in 1580; and being the youngest child, apply'd himself, against the consent of his mother, and without consulting his friends, to the study of physic. He finished his course of philosophy in the year 1594, being the 17th of his age, when he was noted for a great reader, having read *Galen* twice, *Hippocrates* once, and all the other physicians, both *Greeks* and *Arabs*, with great care: and even common-placed the more remarkable passages in them. When, going to *Louvain*, he was appointed, by the professors *Thomas Tyenus*, *Gerard Villers*, and *Hornius*, to read public lectures on chirurgery, in the college of physicians. In the 22d year of his age, being the year 1599, he was created doctor of physic, at *Louvain*.[18]

This we learn from his own writings; and yet in other places he denies he ever was created doctor; but he is not there to be understood in the strictest terms: For that he did take the degree, and in the year 1599,[19] is certain; and there is a register

[17] Shaw and Chambers, **1727,** Vol. I, pages 25–29.

[18] Shaw, **1753,** Vol. I, pages 41–43.

[19] This date is misprinted 1559 in the work from which the passage is quoted.

thereof still extant among the acts of the university. His reason for suppressing the knowledge of his doctorate, was, in his own words, *ne imperiti homines dicerent se peritum promovisse, habuit enim imperitos professores;* lest ignorant unskilful persons, such as he esteem'd the professors, should have the credit of promoting one so well skill'd as himself.[20]

Happening to be troubled with a slight itch, which he could not get rid of by the school-method, but which was easily removed by means of sulphur, he repented having ever devoted himself to the study of physic; considering the nobleness of his birth, and that none of his family had hitherto stooped to such a profession. On these motives he threw it up; divided his fortune among his relations; and quitted his country; with an intention never to return. His books to the value of 200 crowns, he threw aside; and setting out for foreign countries, rambled ten whole years; till being instructed in chemistry by a certain illiterate person, he apply'd himself wholly to that art: and having in the compass of two years obtained a few chemical medicines, he became capable of curing some diseases.

In the year 1609, he married a rich, noble, and virtuous wife, with whom he retir'd to *Wilwoord*, where he gave himself wholly up to the pursuits of chemistry: during his noviciate in the art, he tried many dangerous experiments, which frequently hazarded his life. And tho' he did not visit patients and practise physic for gain, he assures us he cured every year some thousands of sick people. He spent fifty whole years in distillations. He was in high esteem with the *electoral* Bishop of *Cologne*, a prince eminently skilled in chemistry; and was invited by the emporer *Rudolph*, and two other emperors, to the court of *Vienna;* but he always refus'd. In the year 1624, he published a treatise, printed at *Liege*, *de aquis Spadanis*, or, of the *Spaw* waters, and afterwards several other pieces.[21]

As he perceived death drawing nigh him, he call'd his son, *Fr. Mercury ab Helmont*, and gave him the following charge: "Take all my writings, the crude as well as the finished ones; and join them together: to your care I commit them; do with them as you think good. For so it has pleased almighty God, who directs every thing to the best purposes." This son, with whom the deposit was left, was a person of deep thought, and meditation; but a little tainted with enthusiasm; and in his father's life-time had strolled about with a gang of gypsies. After the father's decease, he acquitted himself of the trust, by collecting all his pieces together, and publishing them just as he found them, without any regard to order, consistency, or correctness; and beside, trusted the impression principally to the printer: so that we frequently find *Helmont* relating things in one place, which he contradicts in another.

Indeed, 'tis no wonder we don't find the same tenor throughout; for, as chemistry grew under his hands, and as a world of new views must turn up in the course of forty years, which he spent in gradually improving the art; 'tis easy to conceive how there should arise a difference between the first, and last. The first, faint attempts of a raw unexperienced novice; may well be allowed to differ from the solid productions of a veteran, like *Helmont*...

It remains, that we consider a little, what judgment shall be formed of the man; and, particularly, as to his pretensions to the universal remedy.

He himself protests, in the most awful manner, in presence of Almighty God, and as he expects mercy at his hands; that he has a single remedy wherewith he can cure all diseases, without any kind of evacuation, and merely by correction, or alteration. This we find, not in one place only; but something like it is inculcated in almost all his writings. *A physician*, he says, *who cannot cure the* lepra, *radically, is not worthy the name of a*

[20] Shaw and Chambers, **1727,** Vol. I, page 30.

[21] Shaw, **1753,** Vol. I, pages 43–44.

physician.—A physician, who cannot cure all fevers by one potion of a simple diaphoretic, does not deserve the appellation.—Let every one, who cannot cure all diseases with the alcahest of Paracelsus, *be expel'd the faculty.*—And the like.

But his notion of the origin, and foundation of an universal remedy, is very peculiar, and savours of that enthusiasm which was a part of his character. No poison, says he, can act on a carcass: if, therefore, it have any effect, 'tis by means of life; which life he calls *archaeus;* and ascribes both understanding, and knowledge thereto. If now any heterogeneous body happen to be present to the *archaeus;* it rises into a fervour, endeavours to expel the hostile matter; and, in order to do that, exerts all the force of the body. To cure any disease, therefore, is to pacify, and compose this *archaeus.* This *archaeus,* he holds, is irritated at the least appearance of any thing heterogeneous: and as its office is to watch over the health, and safety of the whole body; it is excited at the very shadow of the enemy, and calls its forces to the charge, raises fevers, and destroys the whole body. The thing required, therefore, is such a remedy as may readily pacify, and lay this unnatural fervour upon all occasions: and this is the universal remedy.

This doctrine of *Helmont* would not be so absurd, did he not ascribe understanding to his *archaeus.* Setting this aside, the principle which renders poisons deadly, and remedies beneficial, is the circulation of the blood. No doubt but *Helmont* was apprized of this before he died. For *Harvey* had published his discovery some years before; which *Helmont* could not but fall into: tho' he might chuse dissembling the matter, in regard it untwisted a good part of his system; which he might want leisure, or inclination to reform, and work a-new.

He adds that *Adam,* had he retain'd his innocency, would have lived for ever; inasmuch, as he would have fed of the tree of life, growing in *Paradise;* but that, upon his fall, God removed the tree of life, and hid it in the heart of metals. If, therefore, we can any how extract it out of the same; we shall stand the same chance for immortality as *Adam* did.

Now, whether *Helmont* had any such remedy, or tree, as he pretends, is the point to be consider'd: if he had, we must certainly find some instance of the use, and effect thereof.

He had three sons; two of which, he owns, he could not cure of the plague, but lost them both: and yet in his book *de Peste,* he expressly declares he could cure the plague and all other diseases.

Again, he had a daughter seiz'd at five years of age with a slight leprosy, which afterwards produced livid ulcers, and dry horny scales over her whole body: he attempted her cure for two whole years successively; but in vain: and yet he is continually boasting, that the alcahest cures the *lepra* immediately; and he swears by the immortal Gods, that he is master of the alcahest. However, instead of applying it, he sent his daughter to the image of the virgin *Mary,* in the hospital of *St. James:* from whence, he ingenuously owns, she returned back, perfectly sound, in an hour's time.

His wife, too, had been sick for some time. He did what he could to recover her; but she laugh'd at him, as not capable of the cure: nor did all his endeavours avail a straw. It happen'd, about the same time, that *Butler,* the famous *English* physician, was clap'd up in prison for counterfeiting the coin; and *Helmont* was sent for to *Brussels,* to be an evidence. Here he contracted an acquaintance with *Butler;* and seeing him perform several extraordinary cures with his stone, he ask'd *Butler* how he came by the secret: *My dear,* answers *Butler,* laughing; *unless you arrive at the cure of all diseases by a single remedy; you'll be but a novice, tho' you should live to the age of* Methusalem.

At his return home, *Helmont* told his wife he had now got her remedy; and that she was to be cured by *Butler*'s stone. Accordingly, the stone being steep'd in oil of olives, and the oil applied to the part affected, she recover'd to a miracle.

Let us now see how he managed his own body, when out of order. If neither his sons, daughter, nor wife were dear enough to him, to make him apply his remedy; yet sure he would not have grudged it on himself.[22]....So far was this mighty chemist from applying any chemical *arcanum*, or universal medicine; that—he took none but the most contemptible *Galenical* ones...

But let us see how he died: He was taken ill of an asthma, which press'd him so, that he was obliged to rise at mid-night, and fetch his breath out at the window. This disease he could not cure; but let it degenerate into a *vomica pulmonis*. His son adds, that he died under a slight suffocation, and *deliquium*, perfectly sensible, and apprehensive of the approach of death. It were needless to ask, what was now become of the tree of life? and why he died at sixty-seven years of age, with the remedy in his power?

In his treatise *de vita longa*, he asserts that cedar-wood, reduced into an *ens* by the alcahest, is that *primum naturae*, one or two drops whereof absterges the matter of all disease, cleanses the blood, restores the vital juice, and revivifies a man every moment; so that with the use hereof it were impossible for him to die. What absurdity! And does not *Helmont* rave? The alcahest he swears he has; and cedar-wood is easily procured; What boots it to protract other peoples days to the longest period; and to die young one's-self.[23]

After Paracelsus and Van Helmont, the number of chemists grew immensely. Boerhaave names the more outstanding figures and tells briefly of their life and works. "The art once form'd, and laid out, there was matter for infinite heads, and hands, to dispose, digest, build, pull down, teach, controvert, pursue, fill up, reduce, and apply it...Here, therefore, we must end our career; the field is too vast to enter on. For chemistry is not only a dark, and intricate, but a dangerous road; and he who enters on it, must proceed, not only with address, but with circumspection, and care."

[22] Van Helmont describes the treatment of his own pneumonia as follows: *Tertio kal. Januarii invasit me repentè febris cum rigore leviculo, sic ut dentes quaterent. Dolor punctilis in latere anteriore circa os Sternum, qui inspirationem praepediret: mox dein sputum cruentem adfuit: tandem merus cruor prodiit. Sumsi statim cervi genitale carptum (nam ad manum erat) & dolor statim imminutus est, mox bibi drachmam cruoris hircini. Quatriduo igitur, cessavit sputum cruoris, persiste tussicula rara, cum aliquot exscreationibus. Perseverabat autem febris. Nam secunda die, dolor circa zonam, latere sinistro sese pandit, cum respiratione difficili, febris augmento, & pulsu intermittente. Absolveram jam annum 63, expectabamque, in splene coagulari apostema...Adeoque suspicatus sum, Pleuritidem è Splene suscitatam, quae cum justis remediis abacta esset è costis, Lienem demum afflixit. Cui statim obveni, potu vini, bulliti cum lapidibus cancrorum. Et infra paucos dies, omnis dolor ac ponderis moles evanuere. ORTUS MEDICINAE*, Amsterdam (Elzevir), 1648, page 397 (first edition). In the *INSTITUTIONES* Boerhaave misquotes the page as *322*. Shaw and Chambers repeat the error in their translation.

[23] Shaw and Chambers, **1727**, Vol. I, pages 32–35.

Culture is the opposite of an absorption with the obvious.—MATTHEW ARNOLD

THE STORY OF PAINT AND VARNISH. PART II

E. C. HOLTON, THE SHERWIN-WILLIAMS COMPANY, CLEVELAND, OHIO

White lead or basic carbonate white lead is the one outstanding opaque white pigment of the centuries. Known to the ancient Greeks and Romans it has come down through the ages and is today certainly the best known and most popular opaque white pigment.

Volumes have been written on this pigment and it will only be mentioned here that in spite of the facts that it is rather poisonous and has been legislated out of use in some countries, that it is darkened by sulfur fumes, that it lacks the dazzling whiteness of zinc oxide and lithopone, that its opacity is less than that of titanium pigments; nevertheless, on account of its general usability and the uniformly good results obtained by its use under normal conditions, it still enters largely into the composition of the best white paints and light tints used for outside painting.

This white lead, which is generally represented as approaching the composition of $Pb(OH)_2 \cdot (PbCO_3)_2$ is often called Dutch Lead because for many years the industry throve in Holland and pigment made by their processes took their name. In France, Germany, England, and America other and quicker processes have been developed and the products sold under various names. Many of these are fully equal to the Dutch in everything but whiteness in which they often are superior.

In addition to the basic carbonate there is another white compound of lead which has been extensively used as a pigment. This is basic sulfate of lead or basic sulfate white lead or sublimed white lead. This pigment is made by a fire process in which lead sulfide ore, galena (PbS), is oxidized and vaporized in a suitable furnace and the lead sulfate fumes travel through a cooling system of pipes to the collecting chamber. This is a very excellent pigment and is not to be confused with a lead sulfate obtained as a by-product in wet processes. Since galena frequently is associated with sphalerite the sublimed lead usually consists of basic sulfate of lead and five per cent or more of zinc oxide. Thus it happens that in the opaque white fume pigments we have zinc oxide free from lead, zinc oxide carrying small quantities of lead, zinc oxide—lead sulfate pigments; varying from 50–50 composition to 75–25; sublimed lead or basic sulfate of lead carrying 10% or more of zinc oxide or lesser amounts even down to mere traces.

There are two blue pigments which are used very extensively today. These are Prussian blue and ultramarine. As already stated, Diesbach made the first Prussian blue but his blue was not so pure and concentrated as the blues of today. Prussian blue is essentially ferric ferrocyanide, yet it contains closely associated with it small quantities of either sodium, potassium, or ammonium compounds. The usual method of preparing

it is to add a solution of sodium or potassium ferrocyanide to a solution of ferrous sulfate. There is formed a nearly white precipitate of ferrous ferrocyanide, which when exposed to air or oxidizing chemicals, rapidly becomes blue.

Blues vary in color tone, and intensity according to the nature of the oxidant used and the method of procedure. This is an art in itself which would require a volume to describe but it can be stated in general that air oxidation is not satisfactory and that careful washing is essential. A somewhat similar blue may be made by reacting on a ferrous salt with a ferricyanide. This is sometimes called Turnbull's blue.

Both ferric ferrocyanide and ferrous ferricyanide are frequently if not always present in Prussian blue. For more than two hundred years this beautiful and intense blue has been preëminent. In mixture with chrome yellow it forms our most important green pigment, chrome green.

In the early part of the last century chemists succeeded in developing processes for the manufacture of the beautiful pigment ultramarine, the equivalent of the very expensive lapis lazuli, which it has displaced. Here again was illustrated the keen scientific and commercial rivalry between two great nations. The prize offered by the French Societe d' Encouragement was given to Guimet of France although many believed it rightfully belonged to Gmelin of Germany. This blue is not injured by alkali but is quickly destroyed by acids whereas Prussian blue is destroyed by alkali and is rather resistant to acids.

Translucents

Non-opaque white pigments or translucents are those colorless pigments whose indices of refraction are so close to that of the paint vehicles that when made into paint they offer but little obstruction to the passage of the visible light rays.

Among the silicates those in common use are silica (SiO_2), clay, hydrated aluminum silicate, asbestine (essentially a magnesium silicate), and other white silicates of the amphibole, serpentine, and talc groups.

Of the carbonates, calcium carbonate is the most extensively used. Whiting is usually made from chalk by wet grinding in edge roll mills and water floating to separate it from the accompanying siliceous particles. Ground limestone is usually made by dry grinding in impact mills and is air floated. Barium carbonate is used to a very limited extent. This is usually prepared by chemical precipitation from barium sulfide solution. Magnesium carbonate also has a limited use. This also is usually obtained by chemical precipitation.

In the sulfate group barium sulfate is most extensively used. The mineral barite is crushed, then finely ground and air floated. Sometimes it is necessary to remove traces of iron oxide with which the mineral is stained.

These are removed by treatment with sulfuric or hydrochloric acid and subsequent careful washing with water. The pigment must then be dried. Blanc fixe, a chemically precipitated barium sulfate is used to a limited extent in paint mixtures, but as a component of composite pigments such as lithopone, titanox, and various lake pigments it is used very extensively. Hydrated calcium sulfate, gypsum ($CaSO_4 \cdot 2H_2O$) is used relatively much less than formerly.

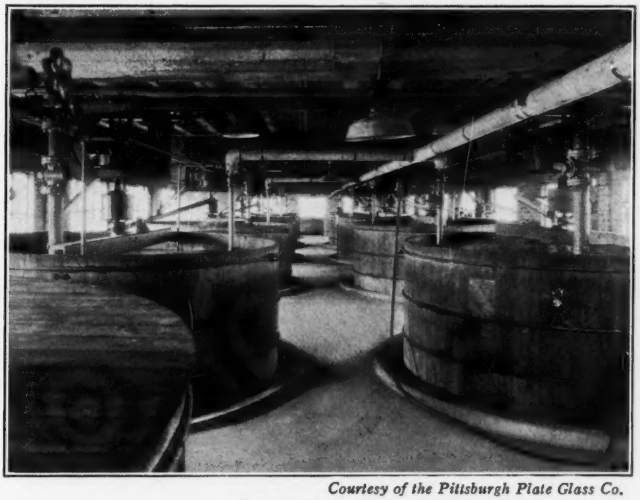
These non-opaque or translucent white pigments, usually being lower priced than white lead, have sometimes been regarded as worthless or nearly worthless adulterants because when used with white lead paint they increased the weight and bulk of the paint and decreased the opacity. In so far as white paint alone was concerned, and during the period when oxide of zinc and white lead were the only opaque white pigments in use, there was some justification for this opinion. With colored paints it has always been a different matter.

Very few of the beautiful lake pigments could be made without the use of one or more of these translucent pigments and even if they could be made some of them would be too expensive to use. Such pigments as chrome yellow, chrome green, Prussian blue, etc., are relatively expensive and their use would be greatly curtailed if it were not for the translucent pigments, which have nearly all the desirable pigment properties except opacity and color. Fortunately, these translucent pigments are usually less expensive than the brightest and gayest colors. Now because of their translucency they may be mixed with these colors without dimming their brilliancy and without changing their tones and this could not be accomplished with opaque white pigments. Much of the beauty in the world today is due to the use of the translucent pigments.

Natural Organic Colors

Until recently various natural organic coloring matters were quite generally used, although in small quantities. Of these the best known are indigo and carmine and Indian yellow. Many natural dyestuffs extracted from wood, bark, roots, and berries have been used in making lake pigments.

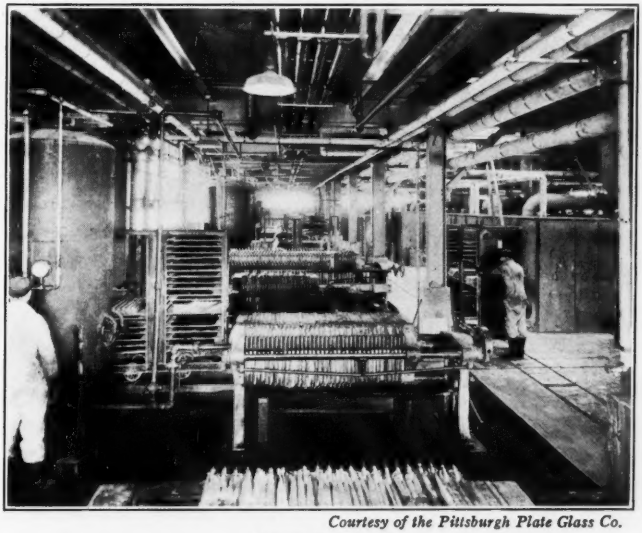
The general procedure was to extract the dyestuff from the material in which it occurred. To the water solution of this dyestuff a solution of alum was added and then a solution of alkali or alkaline carbonate. The usual result was that a considerable part of the color, and sometimes all of it, was precipitated along with the aluminum hydroxide by adsorption, or in some cases chemical combination. Many recipes were developed for the use of various metallic salts, and other chemicals, to produce specific results. These products were called lakes. For use as pigments it was customary to have whiting, silica, barytes, or other non-opaque white pigment present in the precipitating mixture. In this way the lake was



Courtesy of the Pittsburgh Plate Glass Co.

COLOR "STRIKING"

Each set of precipitating tubs has a corresponding tub in the pent house.



Courtesy of the Pittsburgh Plate Glass Co.

COLOR PRESSING

From the tubs in the pent house the material passes by gravity to large receiving tanks on the floor below. From these it is discharged into filter presses.

precipitated on, and in drying became firmly attached to the mineral substratum. The best-known lakes were made from madder, cochineal, Brazil woods, and Persian berries.

The natural organic colors and dyestuffs have now been almost entirely superseded by the synthetic colors.

Synthetic Colors

With the discovery of mauve by Perkin, and the subsequent rapid development of the synthetic dyestuff industry, it was to be expected that attempts would be made to utilize these new dyes in the paint industry. A satisfactory pigment must be insoluble in water and in the paint vehicles used. Many of the new dyes are soluble in water, others are soluble in alcohol, or oil, or other paint vehicles. Some of these dyes, dissolved in their respective solvents, have found use as stains but only those which are reasonably fast to light can be recommended. If they are to be used as pigments they must first be made insoluble.

We have already seen that lake pigments made from cochineal, madder, Brazil wood, Persian berries, etc., have long been used in the paint industry. With the experience already acquired and with the better knowledge of the constitution of the new dyes it became possible for the color makers to work more intelligently. The first basic dyes of the triphenyl methane group were usually fixed by tannic acid, picric acid, arsenic acid, etc., and more recently by tungstic acid, etc. Dyes of the eosin group were usually precipitated as insoluble lead lakes. Dyes in which there are one or more sulfonic groups are usually precipitated as barium and calcium lakes. Dyes in which there are hydroxyl groups are usually converted into aluminum and chromium lakes. It frequently happens that a dye has all three groupings in its molecule and each of these is taken care of by its proper precipitant. Usually these dyes have commanded a high price but on account of their intense coloring power it has been possible to make inexpensive lake pigments by precipitating a small quantity of dye on various mineral pigments.

Of the non-opaque pigments china clay, barytes, blanc fixe, and silica, singly or in mixtures, are most extensively used. Sometimes the dyes are precipitated directly on the opaque pigments but more frequently the above-described lakes are used in mixture with the opaque pigments.

One class of dyestuffs which has assumed great importance in the paint industry is that of the azo pigments made by coupling *beta*-naphthol with the diazonium compounds of *para*-nitroaniline; *meta*-nitroparatoluidine and similar compounds. The former, *para*-nitraniline red, and the latter helio fast red or toluidine toner, are the reds so commonly seen on agricultural implements, vehicles, toys, etc.

The synthesis proceeds as follows:

BY-PRODUCTS FROM THE COKE AND ILLUMINATING GAS INDUSTRIES

Toluol	*Naphthalene*
Treatment with mixed nitric and sulfuric acid	Treatment with sulfuric acid
↓	↓
para-Nitrotoluol	Naphthalenesulfonic acid
Treatment with iron filings and hydrochloric acid	Neutralization with sodium chloride
↓	↓
para-Toluidine	Sodium Naphthalenesulfonate
Treatment with acetic acid	Fusion with caustic soda
↓	↓
Acet-*para*-Toluidine	Sodium *beta*-Naphtholate, crude
Treatment with mixed nitric and sulfuric acid	Treatment with dilute acids
↓	↓
meta-Nitro-acet-*para*-Toluidine	*beta*-Naphthol, crude
Treatment with caustic soda	Distill
↓	↓
meta-Nitro-*para*-Toluidine	*beta*-Naphthol, pure
Treatment with sodium nitrite and hydrochloric acid	Dissolve in water with caustic soda
↓	↓
Diazonium compd. of *meta*-Nitro-*para*-Toluidine	Sodium *beta*-Naphtholate

↘ ↙

Mix
and coupling takes place
↓
meta-Nitro-*para*-Toluene-azo-*beta*-Naphthol
or
Helio Fast Red; Toluidine Toner; etc.

This is a beautiful scarlet pigment, practically insoluble in water and but slightly soluble in ordinary oil and varnish paints, and reasonably fast to light. It may be used by itself or in mixture with many other pigments.

The eosines and xylidine scarlets were used quite extensively some years ago but are now almost entirely superseded by the two reds just mentioned. From the synthetic alizarines, which have superseded the natural madder, lakes of very great light fastness are made and used to a considerable extent. The use of synthetic indigos, the indanthrenes, and the very fast vat colors is slowly increasing.

What Constitutes a Paint or Varnish?

In its broadest sense a paint has been considered as a coloring or protective substance which may be easily and quickly applied to the surfaces

of things. To paint is to color or protect by the application of such a substance. In this sense a colored earth is a paint, so also is a crayon, coal tar, whitewash, and many another substance. Dyed fabrics and electroplated metals are not considered paintings.

Today paint is generally considered in a narrower sense—that is, it is looked upon as a liquid coating composition consisting of pigment particles incorporated with a binding medium. The quality and condition of paint are dependent on the nature of both pigment and binding medium.

Courtesy of Lewis Berger & Sons, Ltd.

OLD-STYLE FILTERING BOX

A section of the dry color department of Lewis Berger & Sons, Ltd., of London (England) in 1900. This plant has a business history of nearly two centuries and the color maker shown had been in its employ for fifty years at the time the picture was taken. In the foreground is seen a very old type of filter press. The wet color is wrapped in linen cloth and laid into the square box, and pressure is applied by placing square stone slabs on top; the escaping water passes through the apertures around the box.

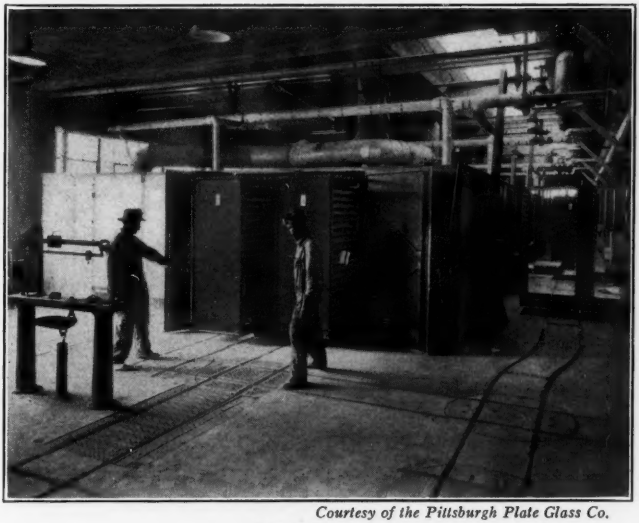
When the binding medium is a liquid the liquid portion of the paint is usually referred to as the vehicle and the solid portion is called the pigment.

Pigments may consist of finely divided metals such as gold, silver, copper, etc., or various mineral substances found in nature such as ochres, umbers, cinnabar, lapis lazuli, barytes, silica, etc., or chemically prepared mineral substances such as white lead, chrome yellow, zinc white or lake pigments made from natural organic coloring matters such as madder and cochineal

or from synthetic coloring matters such as the eosines, the azo pigment colors, the indanthrenes, the alizarines, etc.

The pigment particles usually possess distinctive and desired color such as carbon, black; vermilion, red; ultramarine, blue, etc. If colorless or white, such as zinc oxide or white lead, they have great opacity or they may be quite translucent like silica, barytes, etc. Sometimes opacity is desired and in other circumstances translucency is very important.

From time to time many materials have been suggested and used as



Courtesy of the Pittsburgh Plate Glass Co.

COLOR-DRYING

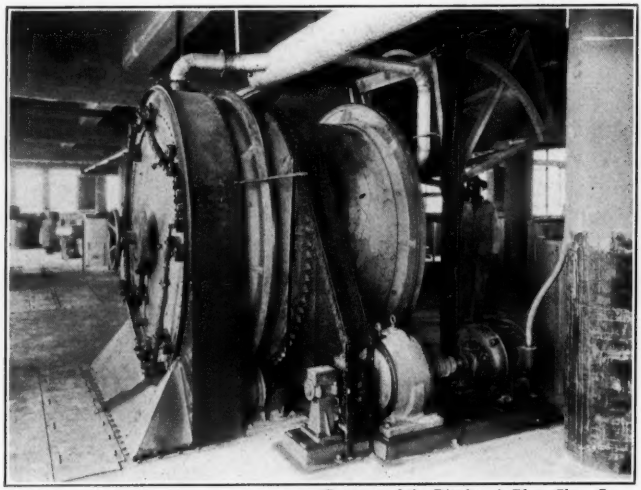
The material removed from the filter presses is placed on trays on racks and taken to the driers. After drying, each rack is passed over a floor scale to weigh the contents.

binding materials for pigments to be used in painting. Formerly waxes were quite generally used. Pigments were mixed with melted waxes and the paint was applied in a melted condition. Vehicles have been made from egg yolk emulsion; white of egg in solution in water; solution of gelatin; water glass solution; water solution of gum, glue, honey, starch, etc., lime water; solutions of resins and waxes in volatile solvents; solutions of resins and drying oils in volatile solvents; drying oils; solutions of cellulose compounds in volatile solvents, etc.

To understand paint, varnish, lacquers, etc., it is necessary to understand what drying is. If strips of paper are moistened by dipping them in different liquids and if they are then hung in the air to dry certain differences may be observed. Papers dipped into ether, alcohol, chloroform,

gasoline, benzine, benzol, ethyl acetate, etc., when exposed to the air rapidly become dry and, except for traces of odor in some cases, there would be no certainty as to which strip had been moistened by any given liquid. If paper is moistened with water, kerosene oil, pine oil, amyl acetate, and certain other liquids, again it is seen that the paper soon becomes dry although not so rapidly as in the first case.

If now the strips are dipped in olive oil, peanut oil, maize oil, linseed oil, perilla oil, tung oil, and other animal and vegetable oils known as glycerides,



Courtesy of the Pittsburgh Plate Glass Co.

COLOR DRY BLENDING

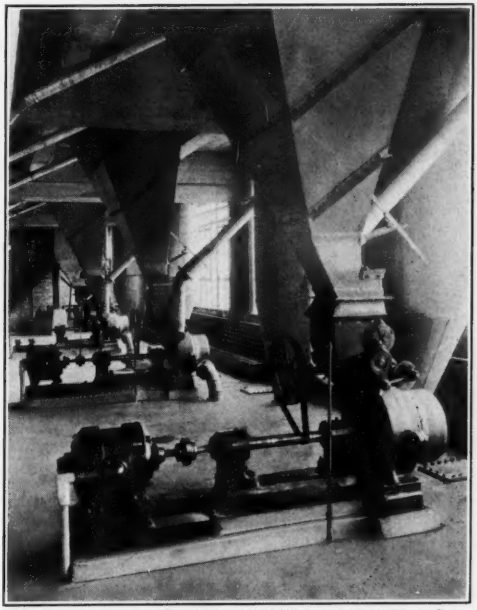
With this apparatus, which holds two to four tons, containers from several different batches are mixed together, resulting in a degree of uniformity heretofore unobtainable.

great differences are seen. These oils do not disappear. In every case the paper continues to be oily for a considerable time. After an hour or so the tung oil changes its appearance, becomes less oily, develops a crinkly surface, and becomes solid or dry. It has disappeared only in the sense that it has changed from the liquid to the solid state. After two or more days the perilla and linseed oil act in a somewhat similar way, although they do not develop so crinkly a surface, and finally they are solid or "dry." The maize, olive, and peanut oils do not become dry in a few days. They thicken somewhat, the maize oil shows a tendency toward drying while the olive and peanut oils remain oily indefinitely.

In the paint, varnish, and lacquer industries those liquids which "dry" like water, alcohol, spirits of turpentine, etc., by disappearing into the

air as vapors are called volatile solvents. Those animal and vegetable oils which do not disappear as vapors but become "dry" by solidification are called drying oils. Those oils which remain oily or greasy indefinitely are called non-drying oils. Other oils which dry very slowly are called semi-drying oils.

In this country three vegetable drying oils are extensively used in paints and varnishes. These are linseed oil, China wood oil (tung oil), and perilla oil. Other vegetable oils such as castor oil, soja bean oil, poppy seed oil, and some others are used in much smaller quantities. This also holds for menhaden fish oil and other marine animal oils.



Courtesy of the Pittsburgh Plate Glass Co.

DRY GRINDING

The material passes from the blender to the hopper and then to the pulverizer.

The best known drying oil, the oil which has been used in painting to a greater extent than any other, is linseed oil, the oil of flax seed. Flax, the *linum usitatissimum* of the Romans, is extensively cultivated in many parts of the world. India, Russia, Argentine, the United States, and British North West are the principal producers. The seed is carefully cleaned and freed from foreign seeds, crushed, usually steamed, then subjected to great pressure in hydraulic presses. The expressed oil is carefully filtered and is ready for use as raw linseed oil. Raw linseed oil when exposed to the air in a thin film becomes solid or dries in about 72 hours.

This drying may be considerably hastened by the addition of substances known as driers. Compounds of lead, manganese, and cobalt are commonly used for this purpose. The most active driers are made by forming oil-soluble compounds of one or more of these metallic elements. These driers are usually made by heating the oxides of these elements with linseed oil and resins in a kettle. A concentrated drier made in this way although liquid when hot, solidifies on cooling, and is inconvenient to use;

therefore, it is customary to dilute this with spirits of turpentine or a petroleum solvent and the resulting product is known as a liquid drier. A common strength of liquid drier is one that will cause a raw linseed oil to dry in 10 hours or less when 5 to 10% of liquid drier has been mixed with it. Sometimes it is desirable to hasten the drying of linseed oil without the use of volatile solvents and resins. To accomplish this the raw oil may be heated ("boiled") with the drying compounds mentioned until a small amount has dissolved in the oil. The oil thus prepared is called

Courtesy of the Canadian Pacific Rwy.

A FLAX FIELD IN SOUTHERN MANITOBA

"boiled oil" and should dry in about ten hours. This "boiled oil," *i. e.*, boiled with driers, is somewhat darker, a little heavier, and a little less limpid than raw oil.

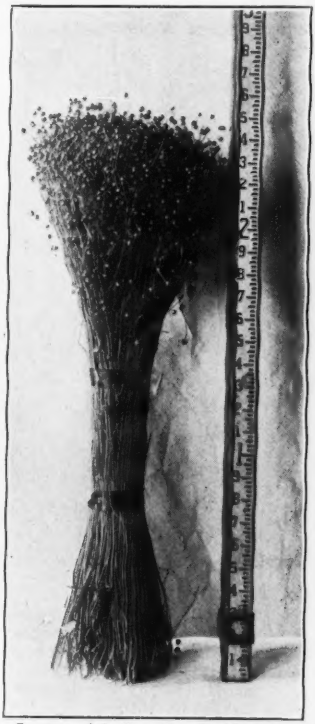
When linseed oil is carefully heated in a kettle, without driers, it gradually thickens, without discoloration, until quite viscous, after which the heating may be continued until it is nearly solid, the product deepening in color until of an amber tone. These thickened oils are called lithographic varnishes and enter largely into lithographic inks and enamel or varnish paints.

In the course of time it was discovered that the resinous exudations of the coniferae when boiled with water or treated with steam yielded a volatile liquid which we now call spirits of turpentine. This distillate has played a very important rôle. It is an excellent solvent for nearly all oils and recent resinous exudations from trees. Freshly distilled spirits of tur-

pentine evaporates completely from a strip of paper, dipped in it and then exposed to the air, in about seven minutes. Exposed to the air in bulk, a portion absorbs oxygen, while the rest is evaporating. The oxygenated portion gradually changes to a resinous substance. Spirits of turpentine when mixed with linseed oil, liquid driers, etc., acts as a carrier of oxygen, absorbing it from the air and delivering it to the manganous compounds which become manganic. These in turn are reduced to the manganous state in the oxidation of the linseed oil. Thus in addition to being an excellent solvent spirits of turpentine is a useful catalytic agent in the paint and varnish industry.

Fossil resins or those resins which have laid in the ground for long periods of time and have undergone a considerable change in their chemical composition usually are insoluble in linseed oil and spirits of turpentine either separately or in mixture. If these resins, however, are heated and partially decomposed, yielding water, terpenes, etc., amounting to twenty per cent or more of their original weight, the residual resin becomes soluble and is suitable for use in varnishes and lacquers.

A film produced by the drying of raw linseed oil is rather soft and possesses little luster. A film produced from oil to which liquid drier has been added is firmer and more lustrous. An oil boiled with driers also gives such a film.



Courtesy of the Canadian Pacific Rwy.

A SHEAF OF FLAX

Varnishes

For many purposes it is desirable to have a finish of even greater hardness and deeper luster. This is obtained by the use of varnish or rather oil-resin varnish which is a composition of a drying oil, a hard resin, and a volatile solvent. The best varnishes of recent years have been varnishes of this type in which linseed oil, or other drying oil, heated to approximately 600°F. is mixed with a fossil resin which has been melted at this or even higher temperatures and kept hot until it has changed to a condition in which it is soluble in linseed oil and spirits of turpentine mixtures. In this country when we use the single word varnish, this type of varnish is usually understood.

A long oil varnish is one of this type in which the amount of oil present nearly equals or exceeds the quantity of resins used and a short oil varnish is the converse of this. Generally speaking, the long oil varnishes are more durable than the short oil varnishes while the latter have deeper luster than the former. There are many varieties of oil-resin varnishes varying in their properties according to variations in qualities and quantities of oils and resins employed.

The pine forests of our southern states have supported a flourishing industry for many years. The gum turpentine, which flows from the

Courtesy of the Turpentine Rosin Producers' Assoc.

TURPENTINE DIPPING

The gum or "dip" as it is called, flows over the face to the cup. When the cup is filled it is emptied or "dipped" into buckets, then into barrels (50 gallons each) and hauled to the still. The dip is a solution of the resin acids in spirits of turpentine. The stilling vaporizes the spirits and leaves behind the resin acids or "rosin."

incisions made in the bark of the trees, is collected and carried to stills where the spirits of turpentine is driven over with steam, condensed and collected, and the residue in the stills becomes the rosin or colophony of trade. This rosin differs greatly from the hard fossil resins and the varnishes formerly made from it were unsatisfactory, since they were lacking in hardness and durability. Fortunately processes have been developed for the commercial production of very durable glycerol and other esters of rosin which when combined with China wood oil and linseed oil produce varnishes of the highest quality.

The fossil resins have come to us mainly as follows: amber from northern Europe, copals from East Africa and West Africa, the East Indies, southern Asia, New Zealand, and the Philippines. For the last forty years the most popular varnish resin has been the New Zealand kauri. With the gradual exhaustion of the known New Zealand deposits the use of copals from the Belgian Congo has greatly increased. The glycerol esters of rosin which are made from rosin and glycerine by a condensation and splitting off of water are entering into serious competition with the fossil resins.

The synthetic phenol-formaldehyde resins and other related compounds and the *para*-coumaron resins made from coal tar distillates are also beginning to displace the natural resins in varnishes.

In addition to this usual varnish of commerce, *i. e.*, the oil-resin varnish, there are other varnishes such as the natural varnishes consisting of the sap or juice of certain trees growing in Oriental countries. The lacquers of China, Japan, and India are of this class. There is also a class of varnishes known as spirit varnishes. These varnishes are ordinarily made by dissolving a resin or a mixture of resins in a volatile solvent such as spirits of turpentine, or benzol, or petroleum distillate, or alcohol, or ether, or ester, or ketone, or a mixture of two or more of these solvents. These are sometimes dissolved without heat, "cold cut," or the solvents may be added to the resins after simply melting them, or in the case of some fossil resins it becomes necessary to first fuse and partially decompose them until they become changed into soluble resins. Shellac mastic, dammar, sandarac, and spirit-soluble manila are the resins most frequently used in these spirit varnishes. Synthetic resins of the phenol-formaldehyde type are also being used in this way. Spirit varnishes containing little of the resin and much of the solvent have frequently been called lacquers.

Cellulose varnishes constitute another class which differs from the older type of spirit varnish in that instead of a resin a compound of cellulose is used. This class is subdivided into cellulose acetate varnishes and nitrocellulose varnishes, the latter being also known as pyroxylin varnish, zapon varnish, celluloid varnish, etc. These cellulose spirit varnishes have also been called lacquers. As already stated, lacquers heretofore usually have been considered as those varnishes which produce a very thin, hard, lustrous coating. The term "lacquer" is being used very generally today to include both quick drying varnishes and quick drying paints in which more or less low-viscosity nitrocellulose is used.

Although varnishes are usually classified as outlined, the dividing lines are not sharp. An oil resin varnish having very little oil and much resin may be considered as a spirit varnish to which a little oil has been added. In the same way cellulose spirit varnishes merge into resin spirit varnishes, in some there is more of the cellulose ester and less of the resin while in others the converse is true.

For many years spirits of turpentine was the one preëminent solvent and reducer for paints and varnishes. Solvents such as gasoline, benzine, kerosine, etc., were prepared from petroleum by distillation and benzol, toluol, and other solvents were distilled from coal tar and drip oils obtained from the illuminating gas industry but there was a prejudice against the use of any of these. With the rapid growth of the ready mixed-paint industry in the United States it became evident that spirits of turpentine would soon be exhausted and distillers of petroleum soon succeeded in supplying the industry with petroleum solvents which for many purposes satisfactorily displace spirits of turpentine.

THE TEACHING OF ELEMENTARY CHEMISTRY

Chemistry teachers who plan to attend the Institute of Chemistry of the American Chemical Society, Evanston, Ill., July 23 to August 18, 1928, will be particularly interested in the announcement of an Institute lecture series on "Content and Method in the Elementary Chemistry Course." As in all other lectures at the Institute, the privilege of attending these lectures is open to all members. Differing, however, from other lecture series at the Institute, these lectures may, if desired, be taken for credit (3 semester hours) in Northwestern University; as such, the course is Chemistry SCx. This privilege is extended to qualified teachers of chemistry who are attending the Institute of Chemistry. There will be frequent discussions and quizzes for those who elect this course for credit; the regular summer school fee is required.

Especially noteworthy is the fact that six leading university professors of general chemistry, representing six different institutions, are to coöperate in offering this series of lectures. These include:

Professor Harry N. Holmes of Oberlin College
Professor B. S. Hopkins of the University of Illinois
Professor Victor K. LaMer of Columbia University
Professor W. T. Read of Texas Technological College
Dean Gerald L. Wendt of the School of Chemistry and Physics in the Pennsylvania State College
Professor Frank C. Whitmore of Northwestern University.

In part, the scope of the lectures will include thorough treatment of such important phases of elementary teaching as the following: the method of presentation of electronic conceptions; the selection of material from physical chemistry for inclusion in the elementary course, and the preferred methods for its presentation; topics concerning industrial chemistry that should be included in the elementary course, with particular reference to modern practice; matter and energy; a critical survey of teaching methods; etc. It is planned to give two lectures daily—one at 7.50 A.M. and one at 9.00 A.M.—for the entire duration of the Institute.

Those who are interested in this course should notify Dr. Charles D. Hurd, Executive Secretary of the Institute of Chemistry, Evanston, Ill. Room reservations in special university dormitories will be made in the order of their request.

PRACTICAL CHEMISTRY IN 1830

M. J. McHENRY, HENDRIX COLLEGE, CONWAY, ARKANSAS

The year 1830 is now practically one hundred years past. It may be regarded as the turning place in a great struggle, the combat of old established opinions against new and revolutionary thinking. This was the time of John Dalton (1766–1844), the Quaker school master, who in 1803 gave to the world his atomic theory. Humphrey Davy (1778–1829) had just died. Only a few years previously had Gay-Lussac (1778–1850), announced the law of combining volumes of gases, and Avogadro (1776–1856), given his famous hypothesis. Berzelius (1779–1848), was at the height of his power. Prout had just a little earlier advanced the much-maligned idea that hydrogen was the unit substance of all the elements. This was also the day of Thénard (1777–1857), and even Wöhler (1800–1882), had already synthesized urea.

These men would not be called practical chemists but the point is that previous to this time the chemist had been working by rule of thumb. These men and their companions inaugurated a day of theory which has enabled rapid progress to be made through a process of reasoning.

It is well to stop and see what stage had been reached in practical chemistry one hundred years ago. In order adequately to represent the case I am going to go to a source book and give much in the original words of the writers. The book chosen is dated 1830 and is called "The Chemistry of the Arts" and was written by Arthur L. Porter, late professor of chemistry in the University of Vermont. It is based on Gray's "Operative Chemist" whose preface is dated 1828. It was published by Carey and Lea at Philadelphia. No attempt is made in this paper to give a complete account but general summaries are given and as much of interesting detail as space permits.

The value of research is recognized by Gray. In the preface to the original work, dated Brompton, 1st March, 1828, we find: "The practical chemist ought to be well grounded in general chemical information; and there is no better mode of gaining it, than that of attempting original investigations."

Porter, in his preface to this the American edition, dated Dover, N. H., September 8, 1830, states that improvements have been made in Gray's work. One of these is in the omission of undesirable matter. Thus, he says: "The articles on Electricity and Galvanism, for instance, have been wholly omitted, as having not even the shadow of a claim to a place in a purely practical work on the arts." Perhaps he would not have been so positive in his statement had he had the vision to foresee electroplating, electric steel, and electrical methods for making alundum, chlorine, caustic soda and caustic potash, barium hydroxide, carbon disulfide, carborundum,

phosphorus, cyanides, artificial graphite, calcium carbide, calcium cyanamid, and other nitrogen products.

Twenty-seven topics are treated by Porter. Their names and the number of pages devoted to each are these: Fuel 36, furnaces 68, blowpipes 2, fire-places 44, hot-beds 2, Mill's pyrometer 1, light 13, specific gravity 13, pulverizing apparatus 2, filtering apparatus 4, heating apparatus 3, subliming apparatus 1, common and pneumatic distilling apparatus 15, bottles and funnels 4, gas apparatus 4, apparatus for fitting funnels 2, chemical lutes 4, theory of chemistry 16, airs 9, acids 69, alkalies 84, earths 45, metals 183, combustibles 109, bleaching 20, calico printing 53, dipping in calico printing 38.

The furnace was an important feature of the early practical chemist's equipment. Hence, particular attention is paid to this topic by Porter. On Furnaces in General he discusses the twere, the ash-room, the ash-room entrance, the grate, the fire-room, stoking hole, feeding hole, the throat, the chamber, the opening into the chamber, the vent, the chimney or flue, velocity of the draught, annoyance of smoke, the conical dome, the blast of air. In Furnaces for Chemical Operations in General a number of individual examples are described: the stove-holes, the furnace for the sand-pot and sand-bath, salt boilers, the copper still, the water-bath or Balneum Maris, the steam-bath or Balneum Vaporis, the melting or founder's furnace, the air or wind furnace, Boerhaave's Reverberatory, reverberatory-furnace with a side-chamber, the forge, the blast furnace, portable furnaces, Dr. Black's furnace, Knight's furnace, Aikin's blast furnace, French evaporating furnace, French reverberatory furnace, Macquer's reverberatory furnace, Macquer's lithogeognosic furnace, Calefacteur Lemare or French portable kitchen, lamp furnaces, Dr. Percival's lamp furnace, Baumé's lamp sand-bath, Baumé's lamp water-bath, Baup's lamp reverberatory furnace.

The hot bed or *balneum ventris* was still being used in some laboratories. Fermenting substances were arranged so that the heat of fermentation could be utilized. Sometimes they were put in vaults under rooms. Substances preferred were tanner's bark, horse dung, flax dresser's refuse, leaves or mixtures of these.

Mill's pyrometer acted on the principle of expansion of air when heated. A platinum bulb, protected by a clay crucible with the intervening space filled with charcoal, was attached to a glass manometer, containing mercury, with the upper end closed but composed of a bulb of the same size internally as the platinum bulb.

Of all the oils used for lighting, olive oil had been proved to be best. The advent of gas was hailed as a great convenience and benefit to society. "Crimes cannot now be committed in darkness and secrecy; and as the risk of detection increases, the temptation to guilt is diminished, and thus

coal gas, by the brilliant light it sheds in our streets, has worked and is now working a moral reformation. The house-breaker and pick-pocket dread the lamps much more than the watchman; and no more efficacious measure of police was ever introduced into society than that from gaslights."

The comparative merits of gas from oil and gas from coal had been settled in favor of the former by the chemists but due to the static condition of the people had not superseded candles. "In consequence of oil gas giving, in proportion to its bulk, a much greater quantity of light than coal gas, it has been compressed into strong iron vessels, is easily portable, and our houses and drawing-rooms may now be illuminated by lamps that never need snuffing, sputter no grease, spoil no clothes, make no dirt, and never give a single spark. They may be carried about without danger, and if turned over or let fall, neither spill oil or tallow. In general, they are not yet adopted, because people adhere to old practices and hate novelties; but ultimately they will come into use and we shall be saved both dirt and trouble, and risks of life will be diminished."

The section on specific gravity is remarkably modern. We still use the names of Baumé and Nicholson in our discussions. The balance with one counterpoised balance arm was commonly used then. "Areometrical beads," working on the principle of floating if lighter than the liquid and of sinking if heavier, were used in control work. "They are now used by many of the first distillers and practical chemists, and have been honoured with the highest approbation of some of the principal manufacturing chemists." For manufacturing liquors, thirty different beads would be sufficient but if all liquids must be tested at least three hundred would be required. An ingenious plan was used in boiling down saline solutions to determine the proper time to cease heating: "Mr. Loudon has adopted the use of two beads, one rather lighter than the proper specific gravity of the liquid when fit to use, and the other rather heavier. If both sink, the liquor is not yet brought to the proper point; and, on the other hand, if both float it is too strong: the proper strength being when one floats and the other remains at the bottom."

The problem of seals for joints was dealt with in various ways. The simplest "lute" was a soft wax made by melting eight ounces of beeswax with about one ounce of turpentine. Another method was not so well recommended: "Bladders close the joint still better, if they are soaked in water until they are quite rotten, stink intolerably, and stick to the fingers: they are then to be formed by the hand into rolls, and applied around the joints." A common lute paste was made of linseed meal beat up with boiled starch. Cheese, grated fine, and mixed with slaked lime and water, was recommended. A fat lute was made by beating up some very dry clay with boiled linseed oil. The coating of a vessel, "or corication, in the language of the grandiloquent philosophers," was accom-

plished by a lute made of "a mixture of about two avoirdupois pounds of clay that resists fire, one pound of some other clay that is capable of being melted, two pounds of coarse sand, and an ounce of dry horse-dung, or chaff: the whole must be beaten up with a little water."

Although mainly practical, Porter devotes sixteen pages to theory. It is concerned entirely with the "Doctrine of Definite Proportions" and "Proportional Numbers." Thénard's numbers are considered most practical and are given in detail. Some examples from the table are given here:

17,705 of Azote, Az, combined
with 10,000 of oxygen forms 27,705 protoxide of azote, Az˙
with 20,000 of oxygen forms 37,705 deutoxide of azote, Az˙˙
with 30,000 of oxygen forms 47,705 hyponitrous acid, Az˙˙˙
with 40,000 of oxygen forms 57,705 nitrous acid, Az˙˙˙˙
with 50,000 of oxygen forms 67,705 nitric acid, Az˙˙˙˙˙
Each dot by each Az signifies one atom of oxygen
7,655 of Carbone, C
with 10,000 of oxygen forms 17,655 oxide of carbone, C
with 20,000 of oxygen forms 27,655 carbonic acid, C
27,655 of carbonic acid combined with so much of any basis as contains 10,000 of oxygen, forms a subcarbonate
55,311 of carbonic acid combined with so much of any basis as contains 10,000 of oxygen, forms a neutral carbonate
with 44,013 of chlore forms 51,668 protochlorure of carbone, C Cl
with 66,020 of chlore forms 73,675 deutochlorure of carbone, 2 C Cl3
with 1,243 of hydrogen forms 8,898 protocarboned hydrogen, C H
with 2,486 of hydrogen forms 10,141 deutocarboned hydrogen, C H2

Five specimens of calculations using the proportional numbers are given. I have worked out these same problems, using the 1927 values for the atomic weights, and compared the results. The problems are: "1. How much charcoal, supposing it composed of pure carbone, is necessary to reduce a pound of the protoxide of any metal, as of iron, so that the charcoal may, by uniting with the oxygen gas, form carbonic oxide? 2. In what proportion must nitrate of lime, and sub-carbonate of potasse be mixed, that there may occur a complete exchange of their acids and bases? 3. What quantity of zinc will precipitate the copper from 50 avoirdupois ounces of blue vitriol, or crystallized sulfate of the deutoxide of copper? 4. How much oil of vitriol is required to expel all the nitric acid from one pound of saltpeter?" The answers are as follows:

	Porter's results	The writer's results
1	1272 grains	1670 grains
2	1.195 $Ca(NO_3)_2$:1 K_2CO_3	1.187:1
3	19 ounces	13 ounces
4	Very nearly half a pound	0.48 lb.
5	26.95 lb. $HgCl_2$	27.07 lb. $HgCl_2$
	11.54 lb. NaCl	11.63 lb. NaCl
	19.36 lb. H_2SO_4	19.54 lb. H_2SO_4

Porter gives an alphabetic list of certain elements and compounds, together with their symbols and also with the Proportional Numbers due to Berzelius and to Thomson. I am reproducing a part of the list that differs from current usage.

		M⁻	Mucic acid
A⁻	Acetic acid	M	Muriaticum
Az	Azote	N	Nitricum
B⁻	Benzoic acid	O⁻	Oxalic acid
Ch	Chrome	Pa	Palladium
C⁻	Citric acid	S⁻	Sulfur
F⁻	Formic acid	P⁻	Prussic acid
Fl	Fluorine	R	Rhodium
G	Gallic acid	S⁻	Succinic acid
L	Lithium	T⁻	Tartaric acid

In the complete list, forty-four elements are listed as given today. They are Al, Ag, As, Au, Ba, Be, Bi, Ca, C, Ce, B, Cl, Co, Cu, Fe, Hg, H, I, Ir, K, Mg, Mn, Mo, Na, Ni, N, Os, O, P, Pt, Pb, Se, Si, Sn, Sb, Sr, Ta, Te, Ti, U, W, Y, Zn, Zr.

The slide rule is not favored in making calculations. "Dr. Wollaston has laid down the numbers of the most usual substances occurring in the practice of chemistry on a sliding scale of artificial numbers, by which persons versed in the use of a sliding rule may solve the problems of this kind that most frequently occur, by inspection: but this instrumental arithmetic only tends to prevents persons from acquiring a facility in calculation, and is, therefore, in the long run, a hindrance rather than a help."

In the discussion of Airs the researches of Priestley, De Mart, and Gay-Lussac are referred to as proving that the air is a true chemical compound. The subtle "poisons" in the atmosphere are referred to in no uncertain terms. "If these experiments be correct, they prove that a deadly poison may be infused through the atmosphere, which the art of the chemist cannot detect; but of which we have better evidence than is given by the nicest tests of an analytical chemist, in the pale visages and weakly constitutions of the inhabitants of close and crowded cities; in the unhealthiness of particular districts, and in the important alteration which a change of residence often produces in individuals unaccustomed to such changes."

Sulfuric acid was made by distillation of copperas, the details of which are very interesting. One experimenter obtained sixty-four pounds from six hundred-weight of vitriol.

The original simple process for making sulfuric acid had been so improved that the modern Chamber Process was approximated and production so increased that the quantity used in Great Britain amounted to three thousand tons a year and it could be bought wholesale at less than twopence a pound. The uses of sulfuric acid were given as in bleaching and dyeing, in medicine as a tonic, and as a caustic for fresh wounds. The formula

is given according to Stahl. "On the Stahlian theory sulfur is SH and oil of vitriol SO 33 Aq.; the glacial or icy oil, or anhydrous acid being SO 24 Aq."

Other acids discussed are sulfurous, nitric, nitrous, hydrochloric, oxymuriatic, nitro muriatic, acetic acid and vinegar, carbonic, fluoric, citric, tartaric, oxalic, benzoic, gallic, succinic, prussic, hydro-sulfuric, and aqua regis.

The comments made upon some of these acids are both amusing and instructive. "The fluoric acid is such a disagreeable subject to meddle with, that chemists are not fond of making experiments upon it." Tartaric acid was used by calico printers to take out false colors, to whiten tallow and to make lemonade. Benzoic acid was used only in making the "popular medicine paregoric elixir," and in perfumery. Gallic acid was "used as a test liquor for iron, in analytical chemistry: for washing over decayed writings to restore their legibility; and scarcely for any other purpose." Prussic acid was employed by the physicians in "consumptive complaints." Hydrosulfuric acid was used then, as now, by the analytical chemists. Aqua regis or aqua regia was made by adding nitric acid to common salt and it is added that "the theoretical chemists are not agreed respecting the changes that take place in making this preparation."

Under alkalies a variety of topics is treated. Various compounds of potassium, sodium, and ammonium such as the chlorides, acetates, oxalates, and benzoates are described. The principles of fireworks were fully understood and formulas given for all the different kinds of "fire" for exhibition purposes, as well as for fuses and other articles used in warfare. The method of preparing "smoke balls, to drive men from between decks or hollow casemates" is given in detail, thus antedating modern gas warfare.

Sal ammoniac, known for two thousand years, was used for soldering, for dyeing to modify the shades of various colors, and for adding "in considerable quantity to snuff to make it pungent."

The method for making artificial pearls would be well worth quoting.

The earths, or oxides of certain metals, deal mainly with glass, pigments, porcelain, brick, and alum. The specifications and details for the manufacture of gun flints are given. It is stated that a workman in three days "is able to cleave and finish a thousand gun flints without further assistance." The manufacture of artificial gems and the alteration of gems by heat and chemicals had apparently reached a high stage of perfection. The best window glass was "made from fine sand, with about twice its measure of the best kelp."

The metals which are considered of major importance are Pb, Sn, Cu, Fe, Ag, Au, Hg, Zn, Bi, Sb, Co, P, and Cr. These together with their compounds are given much space. Besides these "there are several others which have not yet been used in the arts; and are only made to be exhib-

ited by theoretical lecturers to their auditors; as palladium, nickel, cadmium, manganese or manganium, tellurium, molybdenum, tungsten or wolframium, columbium or tantalum, selenium, osmium, rhodium, iridium, uranium, titanium, cerium; as also the doubtful metals—calcium, barium, strontium, magnesium, yttrium, glucinum, aluminum; and the still more doubtful—selenium, potassium, sodium, lithium, silicon, and iodium."

A study of the metals shows a knowledge at that time of a great many things and processes that have been improved later only in detail. Thus, it was recognized that the test for distinguishing potassium compounds from sodium compounds was by a platinum solution. White lead was made by the Dutch process. The blast furnaces for iron were well established. Case-hardening was practiced in a limited way; thus, "this case-hardening, as it is called, is effected by heating them (instruments of iron) in a cinder or charcoal fire; but if the first be used, a quantity of old leather, or bones, must be burnt in the fire, to supply the metal with carbon. The fire must be urged by a pair of bellows, to a sufficient degree of heat; and the whole operation is usually completed in an hour." The quartation of gold was regularly practiced. Corrosive sublimate was known by several names, as corrosive muriate of quicksilver, oxymuriate of quicksilver, muriate of oxidated quicksilver, deuto chloride of quicksilver, and deuto chlorure of quicksilver. Calomel was known as sweet sublimate, mild muriate of quicksilver, muriate of quicksilver, muriate of oxydulated quicksilver, proto chloride of quicksilver, and proto chlorure of quicksilver.

Mirrors were made by the use of "an extemporaneous amalgamation of tin and quicksilver. Tin foil is placed on the back of the glass, and some quicksilver is poured upon it, and spread over the surface with a hare's foot. Another glass is then laid over the tin, to drive off part of the quicksilver; and paper and a board being slid on the tin, it is strongly pressed with a number of weights, to expel, by degrees, the superfluous quicksilver, and leave only a crystallized amalgam on the back of the glass."

The subject of combustibles includes a most heterogeneous assortment of topics. It might be understood why liquors, gases, and oils would be included in this group but it is not so clear why soaps, gingerbread, and portable soup should thus be classified. The recipe for portable soup is as follows: "Break the bones of a leg or shin of beef, put it into a digestor that will merely hold it, cover with cold water, boil it gently for eight or ten hours, strain, let it cool, take off the fat, pour into a shallow stew-pan, add whole black pepper a quarter of an ounce, boil away to about a quart, pour it into a smaller stew-pan and simmer gently till it is reduced to the thickness of a syrup, then either pour it into small upright jelly pots, with covers, and when cold paste the joints over with paper; or pour it out upon flat dishes, to lie about a quarter of an inch deep; when

set, divide it in pieces and dry them. A shin of beef of 9 lbs. produced 9 oz. of portable soup, and 2 lbs., 1/4 of meat fit for potting: no other part yields so much."

English coffee comes in for severe criticism. "This (coffee) is more drank on the Continent than in England: indeed, that drank here is a mere slop compared with the foreign, which is, however, of very different strengths, even so far as to be drank unstrained, and of sufficient thickness for a spoon to stand upright in it for a short time."

A recipe for Raisin Spirit is passed on for whatever it is worth: "Raisin Spirit is manufactured for the purpose of giving a brandy flavor to malt spirit. To each cwt. of common raisins are added 34 gallons of water, and after two or three days some yeast is added. When the liquid no longer diminishes in specific gravity, the whole is put into the still and distilled with a quick fire, to bring over as much as possible of the essential oil of the fruit. One gallon of this spirit will give a sufficient flavor to 160 gallons of malt spirit, to enable it to pass for brandy amongst those unaccustomed to the genuine article."

Summary

Practical chemistry of one hundred years ago is described in an old book, the Chemistry of the Arts, by Arthur L. Porter. Many curious things are included in its discussions. A study of this book is interesting as a means of comparing modern practical chemistry with that of earlier times.

Goat Serum Prevents Measles in Children's Hospital. The prevention of measles by serum treatment goes on apace. When measles broke out in the children's ward of the Cook County Hospital, Dr. Louis J. Halpern, resident physician, undertook to stem the tide with goat serum first developed by Dr. Ruth Tunnicliff of the John McCormick Institute for Infectious Diseases of this city.

This serum is produced by immunizing goats by means of cultures of a coccus which Dr. Tunnicliff believes to be the causative germ of measles. It has been used on a previous occasion to prevent measles but only with a small number of cases.

Fifty children, ranging in age from a few weeks to 12 years old, who had never had measles before were treated with the serum, said Dr. Halpern in a report to the American Medical Association. Five of the young patients were ruled out of the series by death from the diseases from which they were suffering when admitted to the hospital. None of these, however, developed measles or showed any signs of serum sickness.

Of the remaining 45, 28 or 63 per cent, were successfully protected while 17 developed the disease but the majority of these experienced it in only an attenuated form. None of the children suffered from the after-complications that make measles a severe menace to very young children.

As a result of this experience, it seems evident, said Dr. Halpern, that goat serum gives efficient protection in a large number of cases and offers the advantage of being more readily available than human convalescent serum, which has seen considerable application for the same purpose, since it can be produced in quantities to meet all necessary demands.—*Science Service*

THE TEACHING OF CHEMISTRY IN GERMAN UNIVERSITIES*

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In undertaking to contribute to this educational conference a discussion of chemical education in Germany, I shall limit myself to pointing out some differences between the German and American systems which have particularly impressed me. With the latter system I am acquainted by first-hand experience only in so far as it is exemplified at Cornell. However, observations made during visits to other institutions and information acquired from other sources seem to verify those points which have struck me as characteristic of American universities in general.

The differences between chemical instruction in Germany and in the United States are not, for the most part, the consequence of divergent aims or methods in the special field of chemistry, but are more fundamentally rooted in the differences between the universities as entireties. Of course, it is possible to cite minor differences in the method of special chemical education. For example, it is the general custom here to initiate chemical instruction with a course in general chemistry, whereas in Germany it is usual to begin with analytical reactions. But these divergencies in practice appear to me unimportant compared to the vast deviations to be encountered in the total university life.

At the outset it will be well to state just what types of institutions we are to compare as universities. The German university is much easier to define than the American, for in Germany there are no private institutions—all are supported by the State and resemble each other strongly. In America considerable variations of kind and rank exist. If we limit ourselves to a consideration of the larger and more prominent of those institutions which bear the name of university we shall be able to deal with a more uniform group. Upon that basis a comparison immediately reveals one striking fact. The American university includes two student bodies—graduate and undergraduate—while the German university has but one. One might at first thought suppose the American graduate students to be comparable with the German student body but I do not believe this to be so. The German students enter the university at the average age of nineteen, which is nearer to the age of freshmen than of graduates. Furthermore, they have had no specialized instruction, whereas graduate students have already begun to prepare for a profession.

The first two years of the American university, in which emphasis is placed upon general education, correspond most closely to the last two

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years of the German high school ("Gymnasium" or "Realschule"). Since no distinct change can be observed, however, in the method of instruction of the American student after the first two years, I prefer to consider the American university, consisting of both graduate and undergraduate students, as a unit in comparing it with the German university.

The most outstanding characteristic of the method of instruction in the American university which a member of a German university notices immediately, is the volume of written work—preliminary examinations and quizzes, tests, laboratory notes, and final examinations—required of the students. Even more surprising than this is the menacing regulation that students failing to pass these tests, are obliged to withdraw from the university. In comparing this practice with the German methods, we will consider for brevity's sake, only the study of the natural sciences. No written test is required of a student of science in a German university during his whole college course. Moreover, the student chooses the lectures which he desires to attend and is responsible to no one for his regular attendance. Thus in his first year, at the age of about 19 years, he enjoys total independence ("Akademische Freiheit"), which, in Germany, is considered of extreme value to the student after the compulsory training in the "Gymnasium." The student must first of all find out for which profession he has particular interest and talent. The formation of his study schedule is left entirely to him. He may be registered in the College of Natural Sciences, but may attend lectures in Medical or Law Colleges. However, not everyone makes use of this extensive privilege. All those who attend the university to learn a profession in the least possible time—and their number is much larger now than before the war—follow only that which is absolutely necessary for them. The privilege of free selection of lectures and the satisfaction of personal tastes is extended to all from the first year but often only the most gifted students avail themselves of this opportunity.

In America we find the institution of elective subjects as opposed to required ones. The time available for electives is very limited during the first years and increases toward the end of the course. In Germany we find just the contrary development. While the student of science has entire freedom of choice at the beginning of his course, he must, once having decided on a certain profession, necessarily devote a greater part of his time, beginning with the third year, to his chosen subject. Accordingly, we see that in Germany the time open for minor subjects ("hobbies") becomes more and more limited as the time spent at the university increases. This is just contrary to the custom here, where prescribed courses are more numerous during the earlier part of the university course.

This concentration on the major subject, to which I have just referred, is quite extensive during the last years of the chemist's training in Ger-

many. Once the student has decided to work for the doctor's degree, the director of his work expects him to devote the whole day to experimental work. Here in America I have noticed that many, if not the majority, of the graduate students working for their degrees, spend half of their time instructing or assisting in the laboratory and consequently can devote only a half day to their thesis problem. One will rarely meet this condition in Germany. In fact, students, who have held a position as graduate assistant, must resign before starting to work for a doctor's degree. A strong objection to this practice is that students are denied the opportunity of earning their living. Those German students, however, who are obliged to do this, solve the problem by withdrawing from the university for a time to earn money; then, supported by their savings, they are able to devote their entire time to the work leading to the doctor's degree.

The problem of making a university training available to the less-well-to-do students is receiving attention in Germany since the war. Due to realization, on the part of the university teachers and members of parliament and the government, of the importance of this problem it has been made possible to exempt a considerable number of students, about one-third, from the payment of part or all of the tuition fees. Here in America, at least at Cornell, there are slightly fewer scholarships available for graduate students than for the freshmen. On the other hand, in Germany a rule exists which prevents exemption from tuition fees during the first semester since the qualifications of the newly entered students are unknown to the professors. Any professor may recommend, however, to a specially appointed committee, that certain students be exempted for the following semesters. Thus a student, who is fortuneless but comes distinctly above the average of his colleagues, may earn such a recommendation during his first semester at the university and continue his studies without payment of tuition fees.

I shall now have to limit my previous statement concerning the lack of control of the zeal of the German student. There always exists a control, wherever by lack of application the interests of his colleagues may be damaged. The student desiring exemption from tuition fees must be recommended not only on the basis of his gifts but also for his industry, since this privilege can be granted only for a limited number of years to prevent the exhausting of the funds available for the purpose. The student who is granted a bench in a chemical laboratory must demonstrate his seriousness of purpose by his use of the place. For the present, in the best-known German Institutes, there is such a demand for laboratory space that many students must be denied admission. Due to the increased interest in the study of chemistry resulting from the war, the number of students applying for admission to the laboratories exceeds the available

space. When this temporary overcrowding has been eliminated, and conditions once more become normal, students may then pursue work in laboratories as independently as that in the lectures.

In many branches of study in the German universities the students are required to pass examinations only at the end of their instruction. In chemistry and the other natural science professions, in which practical exercises are necessary, one does not go so far. The activity of the students in the laboratory is always supervised and promotion to more difficult work is possible only when the student has obtained the knowledge required for the understanding of the exercises. This is ascertained by free discussions with the assistants or the professor. For about three decades, following the suggestions of Adolph von Baeyer, the chemical university laboratories have adopted the general policy of testing the knowledge of the students in the whole field of chemistry before assigning the subject for the doctor's thesis. This is done in the so-called "Verbands Examen" (the name comes from the "Verband der Laboratoriumsvorstande" which founded the examination); it has no official significance. In the Verbands Examen the candidate is first practically tested in qualitative and quantitative analysis during a period of about a week, and then he must answer important questions about analytical, inorganic, organic, and physical chemistry asked by the laboratory director himself or by one of the assistant professors in his presence. Only those passing this Verbands Examen can be admitted to a German university laboratory to begin work in chemistry leading to a doctor's degree. Here again is an interesting difference between the American and German customs. The introduction of this examination was necessary because so many of the students in Germany change from one university to another during their course of study. The possession of a Verbands certificate gives to a student in the new university the same privilege of beginning immediately upon his doctor's thesis. Also the Verbands Examen is free from any written work, and the judgment of capability of the candidate to undertake the doctor's work is entirely dependent upon the personal opinion of the laboratory director in charge.

We can consider the introduction of the Verbands Examen in Germany as an advance in the direction of the rigid examination system prevalent here in the United States. However, one important difference must be noted. The German student is free to choose, within very wide limits, the manner and the time in which he acquires the knowledge necessary to attempt the Verbands Examen. A gifted and zealous student, coming to the university with some knowledge of chemistry and spending from the start the major portion of his time in the chemical laboratory, will pass the Verbands Examen in the end of the fifth or in the beginning of the sixth semester. Another, perhaps not less able student, who, because of

his general interests, attends many lectures during the first semester, will accordingly pass the Verbands Examen later. The same is true, of course, for all less-gifted and less-zealous students. Thus we see that individual ability and speed are determining factors. The laboratory assignment is the only official requirement for preparation for the examination. However, without a certain amount of book study, no student can pass the examination, since the lectures alone are inadequate. The general chemical knowledge required for this Verbands Examen is already equivalent to that required for the doctor's examination given upon completion of the dissertation. At the doctor's examination the candidate is held responsible not only for questions about his own field of endeavor, but also for his "Nebenfaecher" (minor subjects), which are chiefly physics and mineralogy or mathematics. In these minor subjects he is tested at the doctorate examination for the first time during his whole university career.

From what I have said, it will be obvious that I do not believe in any way that the smaller number of tests in German universities facilitates studying for a degree. On the contrary, to pass one examination at the end of the course of study on the total field of chemistry, physics, and mineralogy before examiners, to whom the candidate is but little known, may be more difficult than to pass less comprehensive examinations from time to time during the whole course of study, which latter practice is characteristic of the American university.

It is impossible to decide which system of instruction should be recommended to the exclusion of the other for all students. I believe it would be very sound to prescribe rather exactly the course of study for the major part of the students and that it would be well for the German universities to adopt something along this line. The institution of advisers about which I learned here in America seems quite excellent to me. It is quite valuable for the freshman to have some one whom he may consult on all matters pertaining to his course of study. In Germany, the young student appears to be afraid of directing questions about his personal study to the professor. He is satisfied with second- or third-hand information received from his fellow-students. I believe that the students in Germany would reach their goal more rapidly and more efficiently if an able instructor recommended their time schedule for the first semester. On the other hand, the total independence enjoyed in the German universities offers to a gifted student such stimulations and educational possibilities as are available only to graduate students in America. The student who surpasses his fellows in talent and will-power is not hampered by course work, which is made for the average man. He does not have to devote his time and patience to written examinations, which are made out mainly for the less gifted; he can develop his abilities at will.

Whether the American or German system (as we shall designate them)

is preferable seems to depend upon the relative importance of the average students as compared with the best students. Due to the existing economic conditions, I believe I may say that for the time being, at least, it is the duty of the chemical universities in Germany to take care especially of the best students. At all times this is a good practice if not carried to extremes. In normal times when the ever-increasing number of chemical industries continually calls for more chemists, the universities must take care of a large number of average students in order to supply the demand. If, however, as in Germany today, as a consequence of increasing concentration less rather than more chemists are needed by the operating industries, only the exceptionally trained and able chemist can find employment. It is the common experience of all chemistry teachers in the German universities today that only those of their pupils who really surpass the average can be placed easily in industrial work. For the present, at least, there is no incentive for the universities to pay special attention to the average student, since such students cannot find employment as chemists in Germany after receiving their doctorate. I do not venture to offer an opinion regarding the present situation in the United States. However, if the condition of the chemical industries here begins to approach that of Germany today, a recommendation for the American universities to adopt a system of chemical instruction approaching that of the German universities may be in order.

I am confident that it would be impossible to reform the university system of either Germany or America without first attacking the high-school system of education. The graduate of a German Gymnasium would never submit to the written test system of an American university, since, at the end of his gymnasium education, he is too independent. On the other hand, the graduate from the American high school would only in exceptional cases be fitted for the mental and moral requirements of a German university. Consequently, any step toward the equalization of chemical instruction in the American and German universities cannot be taken without first reforming the system of preliminary training. However, it is not my task to state whether or not such an equalization is desirable. My purpose has been only to direct your attention to some of the characteristic differences between the German and American universities.

U. S. Helium Supply to Be Increased. Helium for American Zeppelins will be obtainable in larger quantities, it is expected, as the result of the closing of a contract between the U. S. Bureau of Mines and the Amarillo Oil Co., of Amarillo, Texas. According to a notice in a recent issue of *Science*, the Bureau is undertaking to extract the helium fraction from natural gas flowing from wells on the company's leases in Potter County, Texas, at a new plant to be constructed for the purpose at Amarillo.—*Science Service*

A COMPARISON BETWEEN EUROPEAN AND AMERICAN METHODS IN EDUCATION

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In the American Chemical Society there is a section devoted entirely to the study of problems in chemical education. In the chemical societies of Europe visited by the writer there was no section devoted to this subject. Those interested in the training of students in chemistry do not resort to mental tests or to vocational guidance as an aid to the intelligent training of students either in chemistry or in any other subject. They make the assumption that the student of superior mind will naturally gravitate toward the profession which is to his liking. The methods of procedure in Europe are different in many respects from those in the United States. In the United States the student is urged not to begin to specialize too early while in Europe he is supposed to have decided when yet in *die hochschule* what he is going to do and to begin to prepare according to the requirements of the particular field into which he expects to enter. The American student bases his decision to enter a field on taste, aptitude, mental tests, and natural inclination. The European student may have had his decision formed for him by his elders.

While college and university training in the United States has for its goal the raising of the intelligence of its young people from all walks of life; in Europe a college or university training is, for some practical purpose, to fit the student for some specific profession. The American method is styled idealistic and the American people called pious because of the aim to raise all strata of society. The European is worried to know where the Americans are to secure men and women to do the menial labor of the nation if all its young people become college bred. In Europe the old idea still prevails that opportunity is for the few while in the United States the idea is that all men are created free and with equal right to opportunity to develop their native talent. In the United States all young people, men and women, whether Jew or Gentile, Catholic or Prostesant, rich or poor, white or black, oriental or occidental (in extraction), republican or democrat, wet or dry, all find the doors of the colleges and the universities wide open to receive them. Such is not the condition in Europe now and the prospects are rather remote for a change. In the United States young men and women may earn their way wholly or in part while attending college; in Europe such a practice has never been in use but since the war the idea is being introduced by American workers. In Europe the idea of one class of society exploiting another class still prevails. The witholding of education and opportunity from the masses makes it possible for this abominable system to survive. H. G. Wells could not enter Oxford University because his parents were not of the aristocracy. A cer-

tain famous chemist could not continue in his position in a certain German University because he was a Jew. In Geneva, Switzerland, certain schools are absolutely closed to those young women who come up from the ranks of the serving class. I have been told that nowhere in Europe is education idealistic and altruistic as in America. They say, "We are very practical over here." This naturally suggests the question as to which is the more practical: to fit a young person for a position for which he may have no natural bent or to make him sufficiently intelligent so that he can adapt himself to whatever may be the circumstances which surround him. In Germany one meets young students entering the university who are going to specialize in eye, ear, and throat diseases. The brutal question is at once suggested as to how they know they will succeed in such a highly specialized field knowing so little of their own adaptability to this work.

The state schools are run on the principle that they cannot afford to spend time educating the youth who do not know at the start what they are going to fit themselves for. In the United States the purpose of the college and the university is to raise the social status and in this we succeed, while the object of the university in Europe seems to be to afford a place for scholars and professors to study and to investigate. In the United States the relation between professor and student is that of companionship while in Europe the idea seems to be to build a high barrier between professor and student. As it was expressed by one professor, "In the United States the professor is always beckoning the student to come nearer, while the professor in the European university is always repelling him with a gesture."

In the United States vacations are used by the students for outing or as a time to earn money; in Europe the students are supposed and expected to use the long vacations for hard study. The courses in chemistry are all given in lectures with no quizzes or examinations during the semester. The roll is never called. If the student expects to pass the course he must be present at each lecture. The course in general chemistry at the University of Geneva is given entirely by lectures. The student has no textbook to consult or to help him to better understand the lecture. Dr. Pictet, who gave these lectures in 1926–1927, told me that if his lectures were published his students would not attend his classes. Asked as to the relative merits of the lecture system and the textbook system the answer was made that a student remembers longer the facts he learns by hearing than the facts he learns by reading. What divergence of opinion may exist on this point in American universities would constitute an interesting problem. Much of the lecturing in European classrooms is very poorly done and in a most uninteresting manner. You need but observe the listless attitude of the students and the barrenness of their notebooks to be convinced of their lack of interest. The boisterous-

ness of European students as they assemble for class is quite a contrast to our well-behaved American students. However, the students show a marked respect for the professor by rising when he enters the lecture room. Students never question the professor while he is giving his lecture.

In the university the course in general chemistry is given entirely in lectures and demonstrations. The student does no laboratory work himself. The lecture demonstrations are very complete and very complicated. The writer has first-hand information as to how lectures are given in general chemistry in four great American universities and is able to state, with no discourtesy to the offerings of his own country, that in none is the demonstration work so well organized and worked out as the demonstration work presented by Dr. Pictet. A great many quantitative experiments are given. The Victor Meyer experiment is given in the lecture room. The experiment with thermit, liquid air, and a great many experiments involving the use of organic compounds are given with all the refinements which the years of investigation have contributed. At the École de Chemie of The University of Geneva, Dr. Pictet has been giving these lectures year after year, perhaps longer than any lecturer in any university of the United States. The presentation of this course has been with him a problem for careful investigation during the years. He has never written a text on this subject perhaps for the same reason that a certain organic chemist in one of our great midwest universities has never written a text on organic chemistry, namely, that he is too busy finding out new things about organic chemistry.

There is a course in general chemistry also given in the college of Geneva but the students taking this course also take the same course over when they enter the university. The laboratory work offered in the college is largely that of preparations. The laboratory work in general chemistry in the United States seems to have no counterpart in Europe. Every course in chemistry seems to be given with the idea of ultimately preparing the student to do research work. It may be stated here that when the student is assigned his problem he is not allowed to waste his time due to careless supervision but is kept on the high road toward his goal and at high speed.

While European students are well and adequately supplied with apparatus and while the professors are given sufficient time for investigation the idea prevails that American students and American professors have more and better equipment and more time at their disposal. It is felt that American professors have more money with which to buy equipment. It is also felt and, with some bitterness, that the spirit of research has passed from Europe to America. However that may be, the fact remains that the American student studying in a foreign laboratory perhaps will absorb more in a given period of time and will also be stimulated more by

working in an environment stabilized by noble accomplishments than he could possibly accomplish in his own country where time has not been able to write a history resplendent with brilliant contributions.

THE PLACE OF SCIENCE IN EDUCATION

There has just been published a report of the committee of the American Association for the Advancement of Science on "The Place of Science in Education."

This report is organized under seven headings as follows and the summarizing sentence is given for some of them:

I. The Committee's Understanding of Its Functions.

II. The Search for Enduring Facts and the Growth of Confidence in the Guidance of Scientific Truth. Science instruction both in school and out needs better organization, more effective coöperation to make even the health knowledge now available function more completely in the lives of people generally.

III. Obligations of Science Knowledge. Science, not to be discredited, must devise effective ways and means of developing in its devotees first and in the whole people ultimately, a sense of moral obligation that will prevent the newly acquired knowledge and method of science serving base ends.

IV. The Science Subjects in Educational Programs. The hopeful element is that the stereotype science courses of the college are being replaced in the earlier years at least by new types, tentative at present but frankly experimental, looking toward a more satisfactory college science sequence. The whole problem needs careful study.

V. Summaries of Types of Specific Studies Relating to the Educational Uses of Science. The above represent but a beginning in the application of the objective scientific method to the problem of science teaching. Such investigations must be multiplied and verified by those truly interested in the scientific solution of such questions.

VI. Those Who Teach Science. A more thorough-going preparation in the fundamentals of science is needed by all who aspire to teach it.

VII. Those Who Have Developed Science. Science as method is quite as important as science subject-matter and should receive much attention in science instruction.

The committee offers the following recommendations:

(*a*) That some organization of national scope, such as the United States Bureau of Education, or the Research Division of the National Education Association be asked by this committee to undertake a comprehensive and intensive study of the situations, tendencies, and needs of science instruction in educational systems.

(*b*) That the services of a field secretary be secured to work with existing agencies, to distribute information on research in science education, to stimulate further research, to operate as a sort of clearing-house agent and to continue the organizing of new groups of science teachers, writers for popularization of science, etc. This field secretary should work under the guidance of the Committee on the Place of Science in Education, or under the guidance of a national council of science teachers as soon as such a council is formed.

(*c*) That a national council of science teachers be organized to advance science teaching, to increase public appreciation of science, and to secure for science teachers increased facilities and a wider usefulness. The services of a field secretary would be very useful in the organization of such a council.

A copy of the full report will be mailed on request sent to Elliot R. Downing, School of Education, University of Chicago, Chicago, Illinois.

A NIGHT IN ALCHEMY*

(A Pageant Presenting the Spirit of Alchemy)

R. D. BILLINGER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

Scene—An Alchemist's Laboratory. The photograph, Figure 1, will suggest a possible set-up. There is a central table on which the tricks are performed. Behind the table there is a curtain of Alchemical Symbols. At the extreme left is a fireplace. A motley collection of jars, retorts and

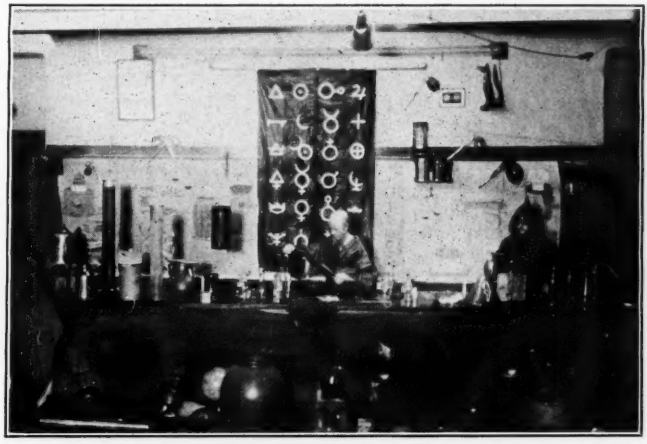

FIG. 1.—A POSSIBLE SETTING FOR "A NIGHT IN ALCHEMY"

old apparatus will lend atmosphere. (Further suggestions will be found in an article by the writer "Illustrating the Black Art," THIS JOURNAL, **3,** 897–902 (August, 1926).)

CHARACTERS

Subtle—An Alchemist. (Portrayed as a shrewd, old faker. Make-up includes bald-wig, heavy beard, and monk's gown.)

Lungs—The Alchemist's Varlet. (A soot-begrimed lackey with a hump-back and patch over one eye.)

Gobbo—A Wanderer who also practises the Black Art.

CURTAIN rises and house is darkened. Subtle appears in a cloud of smoke. This is accomplished with a flash of magnesium powder, and should be accompanied by a pistol shot. A blue spot-light is thrown on the Alchemist.

* Enacted before the Cincinnati Section of the American Chemical Society, February 15, 1928.

Subtle—O, ye generation of unbelievers. Ye, who scoff at true philosophy and alchemy, shall this night see great wonders. You believe that black is black and white is white. Perhaps it is not so in alchemy. And who am I? They call me Subtle; but 'tis only one of many names I go by. I come to you as a messenger of that great Master—Aureolus, Philippus, Theophrastus, Bombastus, Paracelsus von Hohenheim. If the stars are favorable we shall communicate with the spirits of Hermes and Geber. Their spirits will come to us and produce mystic rappings.

(Subtle then invokes the spirits of Hermes and Geber, and the mystic rappings are produced by confederates outside.)

Subtle—O, Hermes Trismegistus—thou who art Master of all Egyptian philosophy, are you there?

(3 raps by confederate.)

O, Geber Abou-Moussah-Djafer Al-Sofi, who holdest the secrets of the Arabs, are you there?

(3 raps by a confederate.)

Ah, the time is ripe for great projection and we shall see an image of our magisterium—the Philosopher's Stone. Now concentrate all eyes on this most bright of fires and presently an image shall appear.

(Subtle now takes a lighted candle, which has been handed to him from below the desk by an Assistant, and lights a small flashlight cartridge of magnesium powder. All the lights are simultaneously extinguished. The brilliant flash leaves an impression on the eyes of the audience which lasts during the period of Subtle's talk.)

Subtle—Now you see the stone in its hazy phosphorescence. Many have sought it, but few have ever attained the goal. What you see now does not exist at all, but is only a product of your imagination. Look closer and you shall see the outlines grow into new form.

(A large phosphorescent skull is now made to appear while the house is still in darkness. The skull, painted with luminous paint, is made to travel over the heads of the audience by means of a long pole or a system of wires.)

Subtle—This symbol represents the end of man, and is what comes to those who search in vain.

(After several seconds the skull is removed.)

Subtle—But enough of this darkness, let us have light.

(As Subtle calls for light, red and green lights are ignited by Assistants at opposite ends of the large table, behind which Subtle is standing. The main lights are now switched on.)

Subtle—Now we will show you simpler things—mere trifles of the Black Art. First of all we must have matter with which to work.

(At this point Subtle snaps his fingers and Assistants toss up bottles or jars to him from behind table. If this business is done properly it will bring a big laugh from the audience as the jars mysteriously appear in mid-air.)

Subtle—I wonder where is my Varlet. He should have kindled my fires long ago. No doubt he is sleeping somewhere.

(Subtle looks around and finds Lungs asleep in large stone jar. Awakens him.)

Subtle—Lungs, you sleepy-head, get your tinder-box and bellows and kindle my fires.

(Lungs makes fire by means of a flint and steel and tinder box. Then pretends to start fire in the fireplace, using bellows, etc. Electric lights in fireplace are switched on. Then he lights seven candles arranged in trough.)

Subtle—Stupid Lungs, I did not tell you to light the seven sacred candles. Put them out with this jar.

(The jar contains CO_2 which extinguishes the candles as Lungs pours it down the trough.)

Subtle—Next, oh, patient ones, I will change water into wine.

(Done by pouring a dilute solution of sodium hydroxide from one goblet into another containing water with a little phenolphthalein.)

Subtle—And converting the wine back to water.

(He pours the colored solution into a third goblet which contains a concentrated solution of hydrochloric acid.)

(This trick may be varied nicely by using only one goblet and two hollow stirring rods. The first rod contains the dilute alkali, and when stirred in the goblet which contains the water and indicator, the red color is produced. Now the first rod is removed and the second rod introduced. The second rod which contains the acid will discharge the red color.)

Subtle—Here I will show you how to change water into milk, and milk into ink.

(This can be done by pouring a solution of strontium nitrate into another solution of ferrous ammonium sulfate. This produces the white colored "milk." Then this mixture is poured into a third vessel containing an aqueous solution of tannic acid. With a little stirring there is obtained a dark colored mixture, resembling ink. These color changes should be done in large goblets of the type used for lecture demonstrations.)

Subtle—From the Seven Seas I have obtained seeds of marine plants which we can plant and make grow before your eyes. Watch, as Lungs sprinkles them in yonder bowl.

(Lungs drops crystals of metallic salts, *e. g.*, ferric, cobalt, and nickel chlorides into a large glass cylinder containing sodium silicate solution. This cylinder should be raised

and illuminated from below by means of an electric bulb. After several minutes the familiar "hanging gardens" will make a beautiful effect. The addition of a little fluorescein will produce a yellowish-green play of colors in the cylinder. Subtle brings in candlestick with five candles.)

Subtle—Here I have a gift from Sandivogius—the magic candles. If you observe them closely they will ignite spontaneously.

(The candle wicks have been dipped in a solution of phosphorus and carbon disulfide, and after standing in the air for four or five minutes, they will ignite. During this interval Subtle gives the following talk.)

Subtle—To those of you who would learn our art I should advise you to consider well the danger, and be sure that better 'tis in safety than in fear to live; and so you shall yourself inure to secrecy, that none from you may hear, either in boasting way, what you can do, nor yet for price procure the secret true. This is an art which does mend nature—change it rather; but the *art itself is nature*. So first of all you must go forth under the open sky and list to nature's teachings. The earth is the Mother of the elements; they proceed from the earth, and they return again to the earth.

The elements are often named from the heavenly bodies. Thus we have ☉ Gold or Sol, ♃ Tin or Jupiter, ☽ Silver or Luna, ♀ Copper or Venus, ♂ Iron or Mars, ♄ Lead or Saturn.

The thumb in chiromancy we give to Venus, the forefinger to Jove, the midst to Saturn, the ring to Sol, the least to Mercury.

And here (pointing to ♁ on chart) we have Sulfur. With the Sulfur of the Philosophers thou canst transform lead into gold, dying plants into fruitfulness, the sick into health, old age into youth, darkness into light, and what not?

Gold, which has been the aim of many selfish seekers, is not formed by any simple process, but only with long and painful steps.

" 'Twere absurd
To think that nature in the earth bred gold
Perfect in the instant; something went before.
We say, it is, of the one part,
A humid exhalation, which we call
Materia liquida, or the unctuous water;
On the one part, a certain crass and viscous
Portion of earth; both which, concorporate,
Do make the elementary matter of Gold.
Which is not yet propria materia,
But common to all metals and all stones.
For where it is forsaken of that moisture,
And hath more dryness, it becomes a stone;

Where it retains more of the humid fatness,
It turns to sulfur, or to quicksilver,
Who are the parents of all other metals.
Nor can this remote matter suddenly
Progress so from extreme unto extreme,
As to grow gold, and leap o'er all the means.
Nature doth first beget the imperfect, then
Proceeds she to the perfect. Of that airy
And oily water, mercury is engendered;
Sulfur of the fat and earthy part; the one,
Which is the last, supplying the place of male,
The other, of the female, in all metals.
Some do believe hermaphrodeity,
That both do act and suffer. But these two
Make the rest ductile, malleable, extensive,
And even in gold they are; for we do find
Seeds of them by our fire, and gold in them;
And can produce the species of each metal,
More perfect thence, than nature doth in earth." [1]

(During this time Lungs has been pottering around—at the furnace, or meddling with jars, scales, etc.)

Subtle—Lungs, clean up my jars and exercise care in your work.

(Lungs dusts jars and finds two scrolls of paper. Brings them to Subtle.)

Lungs—Master, what value are these? They appear to have nothing on them.

Subtle—Ah, Lungs, these are secret messages which were sent to me. Watch closely, as I heat them and you will see the characters unfold.

(As Subtle heats the paper with a candle, a message appears. The message should be prepared shortly before the performance by writing with a dilute solution of sulfuric acid. When the message has completely appeared, the paper is passed around the audience for inspection.)

Subtle—Now I will show you how to inflate balloons without air. As I simply rub these balloons they begin to fill.

(Two toy balloons have been previously prepared by placing inside of each some calcium carbide and a small vial of water. The vial is stoppered with a cork and the balloon itself is tied. When it is desired to inflate the balloon, simply manipulate it so that the cork is removed from the vial and the water spills out and reacts with the calcium carbide. The acetylene generated by the reaction will cause the balloon to inflate.)

Subtle—Lungs, bring me my tea.

[1] From Ben Jonson's "The Alchemist."

(Lungs brings a mug of hot tea and a spoon made of Woods' Metal. As Subtle stirs the tea the spoon gradually melts and disappears.)

Subtle—Sirrah, my varlet, stand you forth and speak—like a Philosopher. Answer in the language. Name the vexations, and the martyrizations of metals in the work.

Lungs—Sir, putrefaction, solution, ablution, sublimation, cohobation, calcination, ceration, and fixation.

Subtle—And when comes vivification?

Lungs—After mortification.

Subtle—What's cohobation?

Lungs—'Tis the pouring on your aqua regis, and then drawing him off, to the time circle of the seven spheres.

Subtle—What's the proper passion of metals?

Lungs—Malleation.

Subtle—What's your *ultimum supplicium auri?*

Lungs—Antimonium.

Subtle—And what's your mercury?

Lungs—'Tis the fugitive element, Sirrah.

Subtle—How do you know him?

Lungs—By his viscosity, his oleosity, and his suscitability.

Subtle—How do you sublime him?

Lungs—With the calce of egg-shells, white marble, talc.

Subtle—Your magisterium now, what's that?

Lungs—Shifting, sir, your elements, dry into cold, cold into moist, moist into hot, hot into dry.

Subtle—Your *lapis philosophicus?*

Lungs—'Tis a stone, and not a stone; a spirit, a soul, and a body. Which if you do dissolve, it is dissolved. If you coagulate, it is coagulated. If you make it to fly, it flieth.[2]

Subtle—Well done, Lungs. Now I will reward you by imparting further knowledge. Listen. Here is the secret of the Philosopher's Stone:

"Roman vitriol is gently calcined and distilled. The distillate is the mercury of the philosophers. The residue is boiled out with water, filtered, and evaporated down. There remains a white earth. This is mixed with the mercury of the philosophers and the mixture digested eight days. (This is the process of conjunction.) Then it is distilled to dryness, mercury again poured upon the residue, and the operation repeated until a little of the residue projected upon red-hot tinned iron entirely evaporates. During this series of digestions and distillations the mass becomes gray and black (putrefactio), but finally white again (albifactio). Now strong fire is applied; the whole mass sublimes (the white swan flies up) and be-

[2] Dialogue with Lungs from Jonson's "The Alchemist."

comes terra foliata. The terra foliata is again mixed with the mercury of the philosophers and heated. It melts like wax. One part of this waxy tincture added to ten parts of molten gold changes this into the Philosopher's Stone. If this does not succeed, the fault is the operator's." [3]

Subtle—Now, Lungs, I must leave you for a little while. Take care that you get into no mischief.

(Exit Subtle.)

(Lungs immediately begins to stir around and try the recipe which was just given to him. He pretends to grind several substances in a large iron mortar. Then he places a small amount of potassium chlorate in the mortar and on top of it a little solution of yellow phosphorus in carbon disulfide. He walks away from this and in a short time the mixture explodes with a loud report. Lungs appears terribly frightened.)

(Enter Gobbo.)

Gobbo—Greetings, oh, Mighty Lungs.

Lungs—Greetings to you, Gobbo, and what dost thou bring, whilst the Master is away?

Gobbo—I bring a basket full of tricks—but tell me, Lungs, did I not hear a forceful blast, and why the tremor in your speech?

Lungs—Had you been here the tremor would have been double, Gobbo—a potent concoction which the Master entrusted to me for the making—seemed to go awrong—perchance it were because of the shorter method I employed.

Gobbo—That, oh Lungs, was your misfortune, for not carrying out the Master's formula. The only thing short about the procedure of yours is—the short way to death itself.

Lungs—Yeah, Gobbo—I believe you speak true words. However, let the past be—out with your tricks, Gobbo, before the Master returns, which means labor for me.

Gobbo—'Tis your own fault, Lungs, that you drudge as a kitchen scullion, for oft have I not said to come with me and entertain the Kings with the magic that I have in my basket.

Lungs—That you have—but the Master seems to have put a spell upon me, from which I cannot break.

Gobbo—Ho, ho, you speak that the Master has made a kitchen slave of you and you speak of magic spells, which you claim the Master can weave about you. Fool, you shall be the slave which you claim to be till the end of time.—Gobbo has spoken.

Lungs—Gobbo, if you ever come in meeting with Master Subtle you will be convinced that I speak the truth.

Gobbo—Come, Lungs, enough of this foolish prattle; I came to entertain you in your misery. Help me so that I may proceed before your Master returns.

[3] From Agrippa's "*De Occulta Philosophia.*"

(Plays Musical Flasks—Gobbo places a row of empty Erlenmeyer flasks of various sizes out in the table and plays a tune on them with small wooden mallets.)

Lungs—O, wonderous Gobbo—That indeed is art.

Gobbo—And look here—see what magic matches I possess. Would not this shorten your drudgery in kindling fires?

(Gobbo takes match, prepared by coating a splint with molten sulfur, and subsequently coated with sugar and potassium chlorate. The match when dipped into concentrated sulfuric acid will ignite.)

Gobbo—Let me show you some of my art. This trick was shown to me by a Venetian painter.

(Gobbo demonstrates flame drawing: This is a very pretty trick which requires several minutes' time. A drawing is made on a large sheet of paper by using a pen and saturated solution of potassium nitrate. The outline will be like that shown in Figure

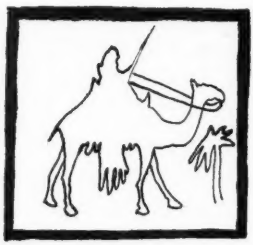

FIGURE 2

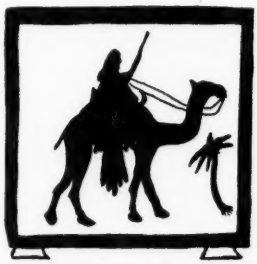

FIGURE 3

2, but is invisible to the audience. When a glowing splint is applied at any point of the outline, it acts like a fuse and the spark travels around the drawing. After the outline has burned around completely, the inner portion of the paper falls out leaving the silhouetted picture as shown in Figure 3.)

Gobbo—Next I will show you a magic gas.

(Generates phosphine gas which ignites in contact with air and then forms rings of smoke.)

Lungs—Oh, that you were the Master—the dark secrets of Alchemy would not remain so turbid. What other wares have you to display, Gobbo?

Gobbo—I have saved the best until last, and if the stars are with us tonight, and the moon shines bright—we shall have a fine day tomorrow.

Lungs—That we shall, but it will only mean drudgery to me.

Gobbo—Now, Lungs, take the taper, for the time is growing short and as I float these magic bubbles, thrust them as the lancers thrust at the tournament.

(Gobbo blows soap bubbles of "detonating gas" (2 volumes of hydrogen with 1 of oxygen) which Lungs ignites with a taper, these explode with considerable violence.)

(After several explosions Subtle runs in.)

Subtle—Gobbo, you wandering Fool, what are you trying to do? Wreck my house with your explosions? Away with you. Lungs, you have taken liberties while I was gone, and now you must slave more than ever. Clean up this mess and hereafter remember your place.

(Subtle now resumes his rôle of portraying tricks to his audience, while Lungs potters around cleaning.)

Subtle—Now, oh, patient ones, I will show you how to make inert matter assume the form of life. This piece of chalk will become a serpent, which will writhe before you as it uncoils itself.

(The material for this consists of mercuric sulfocyanate mixed with one-fourth its volume of potassium chlorate. It can be molded into a cone, formed by using a little alcohol to make it plastic. When ignited it will act like the familiar pyrotechnic serpents.)

Subtle—Fire, which was a mystery to the Ancients, has always been a tool of the Alchemists. It was considered by Aristotle to be one of the primal elements. Watch how Subtle can produce a flame merely by waving a paper in air—and quoting the Chinese expression—"Tsung Hua, Min Koh, Wan Sah."

(This magic flame is produced by having the paper soaked with a solution of yellow phosphorus and carbon disulfide.)

Subtle—Who would hope to light a fire with such a substance as ice? This would surely seem a fallacy. But observe, while I touch this tinder with a piece of cold ice. If my charms still work it will presently ignite.

(On top of the tinder is placed some sodium peroxide, which bursts into flame when water drips from the ice.)

Subtle—My boy Lungs was so named because of the power and quality of his breath. This test will surely show how strong he is.

(Lungs first blows out a flame which is placed at a distance of six feet or more. Then the flame reappears and he again blows it out. The flame is from a gas burner concealed behind several bricks arranged in the form of a fire place. If the burner is arranged with a small pilot flame it may be turned off when Lungs blows, and on again when he stops. This requires the help of an Assistant to manipulate the gas. Lungs makes a great show of his lung power and wheezes with considerable violence.)

Subtle—Just as fire is difficult to make without heat, so ice is hard to produce without cold. But even this secret melts quickly before the Alchemist's power. Note carefully, while I pour two liquids together; and soon I have ice formed. But this is strange ice—for, see what happens as I apply a flame.

(The one liquid is a saturated solution of calcium acetate, the other liquid being ethyl alcohol. On addition of these two a gel-like precipitate forms, which may be removed and exhibited. Of course the product will ignite when a flame is applied.)

Subtle—And now I come to our last and greatest feat—the art of transmutation. The production of gold is a long and tedious process, as ye have learned. But silver I can make quickly as ye shall see, directly. Watch as I immerse this strip of copper into the liquid. Presently it darkens, but when I rub it, you will see silver—fair as Luna.

(A strip of copper is dipped into a dilute solution of mercuric chloride in a battery jar. After a minute it is removed and rubbed vigorously with a cloth to obtain the silvery luster. Subtle passes the coated strip to Lungs.)

Subtle—Here, Lungs, take this sample of our art and stamp out coins for our friends.

(Lungs pretends to stamp out coins, and then takes pennies which have been previously coated with mercury and throws them to the audience.

Subtle—If we have concealed anything, ye sons of learning, wonder not, for we have not concealed it from you, but have delivered it in such language as that it may be hid from evil men, and that the unjust and vile might not know it. But, ye sons of Truth, search, and you shall find this most excellent gift of God, which he has reserved for you. And now let me close with the secret chant of our Order.

Himmel droben, Himmel drunten,
Sternen droben; Sternen drunten,
Das was oben, ist auch unten,
Wer das weiss, hat viel gefunden.

CURTAIN

Acknowledgment is made for the valuable assistance of Messrs. Leslie German and Edward Schlesselman, who contributed largely in suggesting the "business" of the pageant, and participated in several productions.

Television Shown at Physicists' Meeting. Members of the American Physical Society, meeting in New York recently, were able to see by wire through walls and around corners when they were given a special demonstration of the process of television developed by the Bell Telephone Laboratories. This was the process that was used last April in the first successful long distance television tests, when Secretary Hoover spoke in Washington and was seen in New York.

At a session of the society at the Bell Laboratories, Dr. Herbert E. Ives, under whose direction the method was developed, explained its operation, and the recent improvements that have been made on it.—*Science Service*

A STUDY IN UNITS OF VOLUME

K. M. PERSING, GLENVILLE HIGH SCHOOL, CLEVELAND, OHIO

Many chemistry classes at present include students who have not had a course in physics, and are therefore unfamiliar with metric units of measure. It is also true that a considerable number of students who have had a course in physics come to the work in chemistry with a more or less hazy idea of the actual value of metric units of weight and volume. The work outlined herewith has been set up for the purpose of helping students acquire a clearer idea of the two common metric units of volume—the liter and cubic centimeter.

The work consists of the construction of three cardboard measures. They are the liter, the cubic centimeter, and the quart. The construction of a quart measure was included in the work for use in making a comparison of the values, quart and liter. It is surprising to find that with the majority of students, the value one quart is explained in terms of a milk bottle.

The construction work was carried on outside the class-room from mimeographed direction sheets, a copy of which is given below. The finished measures were presented to the instructor for inspection and after being checked were then returned to the student. The measures were kept by the students for any future use and finally were entered in an exhibit of class work.

The results obtained were, from a mechanical standpoint, quite satisfactory and the students seemed interested in doing the work. It may be in the nature of an assumption to say that the students now have a better idea of these metric volumes than they otherwise would have, for we do not have any exact way of determining the value of the idea that has been established. However, the seeming ease with which they use the terms in their work may serve as an index to indicate that the terms are not just formal words. An example of this use of terms may be cited in the conversion work from cubic centimeter values to liters, and vice versa in which students appeared to have little trouble.

THE DIRECTION SHEET

(Copy)

Students in chemistry have occasion to use two metric measures of volume. These measures are the cubic centimeter and the liter. Do you know the approximate amount of sugar or sand that would be required to fill a measure of 1 cubic centimeter volume? Do you know which is the larger, a quart measure or a liter measure? The following piece of work is provided to help the student acquire a clear idea of the actual values of these two important metric measures of volume.

The work consists of constructing several cardboard measures. It is suggested that you construct the liter measure first, as the small size of the cubic centimeter measure might cause some difficulty until you become more familiar with the work.

The Liter Measure

Secure a sheet of light weight cardboard about 50 centimeters (20 inches) long by about 25 centimeters (10 inches) wide. Lay off on this cardboard a drawing similar to the diagram below. The dimensions of each square are 10 centimeters by 10 centimeters. Be exact in all measurements.

Cut out the diagram along the heavy solid lines. Fold on the dotted lines. You will be able to fold the work more neatly if you first crease the dotted lines by drawing the blunt edge of a knife blade along each dotted line. NOTE—Use a ruler in tracing the dotted lines and be careful that the cardboard is not cut by the knife blade.

After folding the box along the dotted lines, apply library paste or mucilage to the tabs marked: "X, X-1, X-2, and X-3." Now fold the box into shape and firmly press

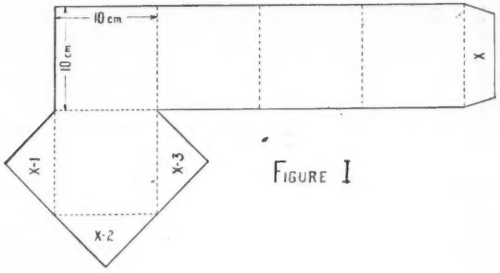

FIGURE 1

"Tab X" into place. This will hold the box in shape. Continue by joining Tabs "X-1, X-2, X-3" to the sides of the box. Press firmly together. Allow paste to dry. (Apply all tabs on outside of box.)

The box, if carefully constructed, will have a volume of 1 liter. Label on one side of the box.

The Cubic Centimeter Measure

Proceed as in the construction of the liter measure. The dimensions of each small block in your diagram are 1 centimeter by 1 centimeter.

Cut out, fold, and paste. After allowing it to dry label—"1 CUBIC CENTIMETER."

The Quart Measure

Proceed as in the construction of the liter and cubic centimeter measures, laying off the diagram on lightweight cardboard. The dimensions of each block in the diagram are 9.8 centimeters by 9.8 centimeters (approximate dimensions which are sufficiently accurate for this work).

Cut, fold, and paste. Allow to dry and then label "1 QUART."

The measures when completed should be presented to the instructor for inspection and approval. When the instructor returns the measures to you, reserve for further use.

Answer the following questions:

1. Of the three measures which you have constructed which is the largest?
2. Assuming that there would be no loss of space, how many of the cubic centimeter measures could be exactly placed in the liter measure?
3. Which has the greater volume—the liter measure or the quart measure?
4. Calculate the number of cubic centimeters in 10 liters.
5. Calculate the volume of 2653 cubic centimeters in terms of liters.

BOILING-POINT CURVES OF MIXED LIQUIDS

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The teacher of an elementary course in physical chemistry is confronted with the problem of picking out the most profitable laboratory experiments to be performed in the somewhat limited time available. The sort of course the writer has in mind is taken by undergraduates majoring in chemistry or related subjects during the senior or junior year and consists of lectures accompanied by one or two laboratory periods a week sometimes for a year but often for only one semester. Due to holidays, mid-year examinations, etc., there are usually available only about twenty-five periods for actual work.

Care must be taken not to spend more time on any topic than it is worth and in planning the course the instructor must have this in mind. It is desirable, of course, to strike a suitable balance between strictly quantitative experiments, semi-quantitative experiments and possibly some that are purely qualitative. Those finally chosen may give practice in the manipulation of special apparatus, such as a Beckmann thermometer or a constant temperature bath; they may make use of nothing more complicated than flasks or test tubes in illustrating physico-chemical principles or both points may be involved—namely, the use of special apparatus and its application in studying fundamental principles. As an example of this latter, mention might be made of the use of the Cottrell-Washburn apparatus in determining molecular weights or the use of a potentiometer in measuring pH values. Other things being equal it seems obvious that it is best to make use of apparatus as simple and inexpensive as possible and to carry out experiments that are the least time-consuming for the results obtained.

One of the most interesting chapters of physical chemistry has to do with liquid-vapor systems—boiling points, vapor pressures, distillation, and the like. Unfortunately, while of much practical importance, the theoretical treatment of the behavior of mixtures of completely miscible liquids is in a rather unsatisfactory state.

If it should happen (as is usually not the case) that the liquids form an ideal solution and we know the values of the vapor pressures at a series of temperatures for each, we can calculate the composition of the liquid at its boiling point and also the composition of the vapor. This is discussed quite clearly by Hildebrand[1] for the case of the presumably ideal solution formed by carbon tetrachloride and stannic chloride. Plotting mol fraction (or mol %) against boiling point, two curves are obtained (Fig. 1), the lower one showing the composition of the liquid and the upper one the composition of the distillate. An inspection of these curves shows

[1] "Solubility" (Chap. IV), A. C. S. Monograph, Chem. Cat. Co., 1924.

that the distillate will always be richer in the more volatile liquid than the residue and it is upon this well-known fact that all fractional distillation is based. If the boiling-point curve has once been found by experiment and we know the vapor pressure-temperature relationships of the components, it is possible to work back and determine if the solution is an ideal one.

Mixtures which are met with in practice may approximate ideal solutions in their behavior, but frequently show wide variations, the complete explanation of which is not well understood. In many cases the curve shows a minimum while in others there may be a maximum. Ninety-

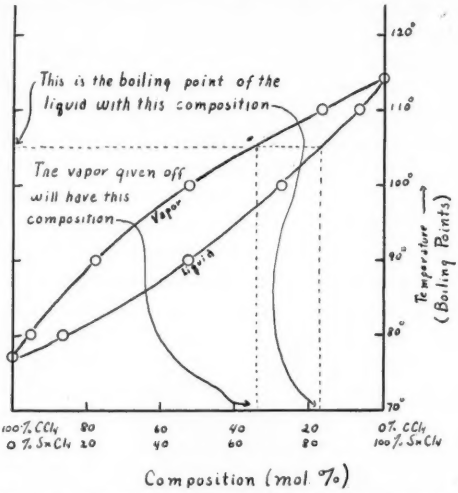

FIG. 1.—"IDEAL" BOILING POINT—COMPOSITION DIAGRAM

five per cent ethyl alcohol has a lower boiling temperature than the absolute and many other liquids behave in a similar way, although exact data is often lacking. The most familiar examples of the other extreme are mixtures of certain acids and water. The composition of the maximum boiling point hydrochloric acid has been studied by a number of investigators[2] and several laboratory manuals describe instructive experiments to show the gradual formation of this mixture when either dilute or concentrated hydrochloric acid is distilled. The distillate is at first richer in the more volatile component (water or gaseous hydrogen chloride) but as the distillation proceeds, the distillate and residue finally reach the same concentration after which no further change takes place.

[2] See, for example, Foulk and Hollingsworth, *J. Am. Chem. Soc.*, **45**, 1220 (1923). Additional references are given in this article.

While it is in general impossible to predict what the behavior of an unknown pair of liquids will be[3] it is interesting as well as important to show experimentally the types which are possible. Certain manuals[4] give the experiment with hydrochloric acid outlined above and one to show a minimum boiling point. The ideal type is usually left to the course in organic chemistry where its relation to the others may not be emphasized. It would seem desirable to have all three types studied at the same time. Fairly pure materials are required for the work and the methods usually given require relatively large quantities. For classes of even moderate size it is rather time-consuming to prepare enough of the purified substances even if one follows the scheme[5] of having the student proceed from one distilling outfit to another. To follow the method of Davison and Van Klooster[6] special apparatus is required as is also the case with the more exact method given by Sherrill. The latter describes this as giving "reasonably good results when executed by careful students or with close supervision of the instructor but. . .not well suited for the use of large classes working under a limited time assignment."

It occurred to the writer that it might be possible to apply one of the boiling-point methods requiring only a small quantity of the liquid. These were developed for use with pure substances rather than mixtures and in one of them[7] the authors mention a change in boiling point taking place when successive determinations were made with impure liquids. The same error is, of course, inherent in the distillation methods also. Smith and Menzies "submerged bulblet" method, which is applicable to either liquids or solids, was tried out and, while it gave fairly good results, was dropped due to the difficulty in filling the bulbs without boiling away too much of the more volatile liquid before the actual determination was begun.

The method finally adopted is that of Siwoloboff[8] and consists in placing about 0.5 cc. of the liquid in a small fairly thin-walled tube which with a thermometer is immersed in a well-stirred bath of a suitable heating liquid. In the liquid under examination is placed a capillary tube about 2 cm. long and 1 mm. in diameter, open at the bottom and closed at the

[3] See, however, Appendix III of Robinson's "Elements of Fractional Distillation," McGraw-Hill, **1922.**

[4] For example, "Laboratory Experiments on Physico-Chemical Principles," Sherrill, Macmillan, **1923.**

"Laboratory Outlines in Physical Chemistry," Briggs, Ithaca, N. Y., **1926.**

"Laboratory Manual of Physical Chemistry," Davison and Van Klooster, John Wiley and Sons, Inc., **1922.**

[5] Sherrill, *loc. cit.*

[6] *Loc. cit.*

[7] Smith and Menzies, *J. Am. Chem. Soc.*, **32,** 897 (1910).

[8] *Ber.*, **19,** 795 (1886). See also O'Dowd and Perkin, *Trans. Faraday Soc.*, **4,** 95 (1908).

top. These are most easily made by drawing out tubing to a length of 6–8 cm., cutting the thin part out and melting it together in a small flame at a distance of 2 cm. from one end. The long part then serves as a handle. With the capillary in the liquid the bath is heated with constant stirring. Bubbles of air escape at first from the lower end of the capillary and when the boiling point of the liquid is slightly exceeded there will be a rapid stream of bubbles of vapor. The outer bath is then allowed to cool (constant stirring!) and when the bubbles cease and the liquid starts to suck back, the thermometer is read. This reading gives the temperature at which the total pressure inside the capillary is equal to the external pressure—in other words the boiling point. With a pure liquid the process may be repeated a number of times, but with mixtures this is inadvisable unless the superheating has been very slight. The reason for this is the change in composition of the mixture on boiling. It is often possible, however, to get two readings less than a degree apart.

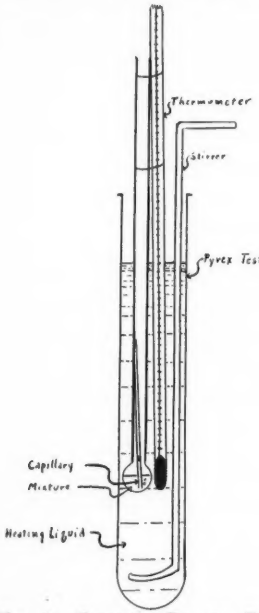

FIG. 2.—STUDENT BOILING-POINT APPARATUS

The general set-up of the apparatus (Fig. 2) may be varied more or less. The writer prepared small tubes about 15 cm. long from ordinary 6 mm. "wash bottle" tubing, blowing a small bulb of fairly thin wall at one end to hold the liquid. One of these was fastened to the thermometer by rubber bands and immersed in the heating liquid (water or sulfuric acid) contained in a large Pyrex test tube. The bath contained a hand stirrer and was heated with a small burner. To make the determination the liquid is added to the bulb tube and the capillary dropped in. The bath is then heated and allowed to cool as described above. After a determination is finished, the remaining liquid is shaken from the bulb and the latter placed in an oven where it will dry quite rapidly.

Efficient stirring is, of course, essential, particularly if such a small bath is used. A test tube was chosen merely to save time in making a determination as the liquid can be heated rapidly to the desired temperature. It was found to give satisfactory results with the mixtures used. To show a very small difference in boiling points, such as that between 95% and 100% ethyl alcohol (0.26°) a larger bath would be necessary.

The particular mixtures chosen for study were the following: benzene-toluene, ethyl alcohol-ethyl ether, chloroform-acetone, and methyl alcohol-chloroform. Starting with 5 cc. samples of one liquid (*e. g.*, benzene) mixtures containing 0, 20, 40, 60, 80, and 100 mol % of the other (toluene) were prepared. This requires only 25 cc. of benzene, less than 50 cc. of toluene and makes enough for about 10 students.

The mol % of toluene is given by the expression

$$\frac{(a)\ (0.86)\ (78)\ (100)}{(5)\ (92)\ (0.88) + (a)\ (78)\ (0.86)} \text{ or approximately } \frac{a}{6 + a} \times 100$$

0.86 and 0.88 are the densities and 78 and 92 the molecular weights of the two liquids. "*a*" is the volume of toluene to be added to the 5 cc. of

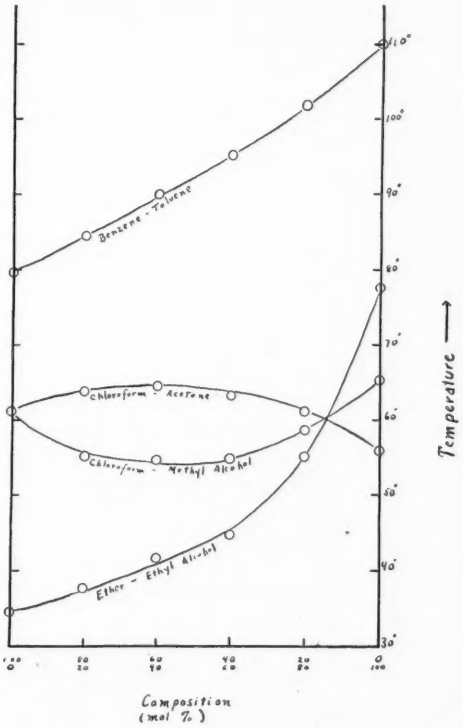

FIG. 3.—CHARACTERISTIC BOILING-POINT CURVES

benzene. From this it is apparent that to make the 20% mixture, 1.5 cc. of toluene must be taken and 4, 9, and 24 cc., respectively, for the 40,

60, and 80% mixtures. The quantities of the other substances are determined by a similar method.

A class of eleven students was divided into four teams, each of which carried out the above calculations and prepared a set of mixtures for the use of all. Working individually each student then prepared at least some of the capillaries, assembled his own apparatus, and carried out the boiling-point determinations on two sets of liquids—twelve determinations in all. One laboratory period was found to be ample time for most students. The slower ones took somewhat longer.

Some experimental results are shown graphically in Figure 3. They agree well with the results obtained by distillation. Benzene-toluene and ethyl alcohol-ether are seen to approximate the ideal curve, while of the others, one shows a maximum and the other a minimum. It is evident that benzene and toluene or alcohol and ether could be separated by fractionation while the others would act like hydrochloric acid or an aqueous solution of ethyl alcohol. While no quantitative information is given regarding the composition of the distillate, it should theoretically be possible to separate the pure liquids from either the maximum or minimum boiling mixture. Practically this is possible only when there is a decided difference in their boiling points.

In addition to its simplicity and economy of materials several pedagogical features of this work may be mentioned. An experiment taking only one laboratory period illustrates the meaning of mol % and gives practice in making calculations regarding the same. It illustrates an important method of determining boiling points for both pure liquids and mixtures. It illustrates the relation between vapor pressure and external pressure when the liquid is at the boiling point and when superheated. It illustrates the difference between ideal solutions and others. It illustrates the behavior of the three types of binary mixtures of miscible liquids, at the same time giving data with which to prepare temperature-composition diagrams for such two-component systems.

Summary

The need is pointed out for a simple experiment illustrating the difference in behavior of the various types of mixed liquids from the viewpoint of the theory of distillation.

Such an experiment has been devised, use being made of the Siwoloboff boiling-point method, which is shown to give reasonably accurate results when applied to mixtures.

The pedagogical features of the proposed experiment are mentioned and a brief discussion of distillation in general is given.

THE DISPLACEMENT SERIES AS A SOURCE OF EFFECTIVE CHEMISTRY TEACHING

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The classification of the metallic elements according to their decreasing chemical activities is known by several names: the displacement series, activity table, electro-chemical series, electro-motive series, and perhaps others. The most suitable name from the point of view of the teacher of chemistry is the activity table although the term "universal table" would more fully indicate the uses to which it might be put.

It is not out of place at this time to describe the method by which the activities of the metals may be determined. When certain metals are treated with acid solutions, hydrogen ions of the acids are freed and equivalent weights of the metals enter the solutions in the form of ions. Energy is liberated during the reaction as may be shown by immersing the bulb of a thermometer in the solution during the reaction. The energy, liberated in the form of heat, causes a rise in the mercury column of the thermometer. Experiment shows that metals differ in their ability to react with acids and that the energy liberated during reaction is different for each metal. To demonstrate this difference in activity let us treat gram-molecular weights of magnesium and of zinc with hydrochloric acid solutions of the same concentration. The magnesium is dissolved long before the zinc and a thermometer indicates a higher temperature in its solution. While a thermometer does not measure heat, the use of a calorimeter would show that more heat was liberated by the magnesium than by the zinc. The following equations show the results of such an experiment:

$$\overset{\circ}{Mg} + 2\,\overset{+}{H}\overset{-}{Cl} = \overset{++}{Mg}\,\overset{-}{Cl}\,\overset{-}{Cl} + \overset{\circ}{H_2} + 108{,}300 \text{ calories.}$$

$$\overset{\circ}{Zn} + 2\,\overset{+}{H}\overset{-}{Cl} = \overset{++}{Zn}\,\overset{-}{Cl}\,\overset{-}{Cl} + \overset{\circ}{H_2} + 34{,}200 \text{ calories.}$$

The difference in the activity of magnesium and zinc = 74,100 calories. It would be expected that if magnesium were introduced into a solution of zinc chloride, the magnesium would displace the zinc and liberate 74,100 calories. By experiment this is found to be true. The greater the energy difference between two metals the greater the displacing power of one. Comparing the activity of magnesium and iron:

$$\overset{\circ}{Mg} + 2\,\overset{+}{H}\overset{-}{Cl} = \overset{++}{Mg}\,\overset{-}{Cl}\,\overset{-}{Cl} + \overset{\circ}{H_2} + 108{,}300 \text{ calories.}$$

$$\overset{\circ}{Fe} + 2\,\overset{+}{H}\overset{-}{Cl} = \overset{++}{Fe}\,\overset{-}{Cl}\,\overset{-}{Cl} + \overset{\circ}{H_2} + 3200 \text{ calories.}$$

The difference in activity of magnesium and iron = 105,100 calories. Magnesium, therefore, has the power of displacing iron from its solutions and the displacement is more rapid than the displacement of zinc. Zinc will also displace iron and iron follows it in the series.

By repeating the above experiments it will be found that of all the common metals, potassium is the most active, then sodium, calcium, magnesium aluminum, zinc, iron, etc. The arrangement of the metals in this order is called the series:

K, Na, Ca, Mg, Al, Zn, Fe, Ni, Sn, Pb, H, Cu, As, Hg, Ag, Pt, Au.

It is not expected that the teacher of chemistry shall deal with the development of the series with beginners in chemistry. This may be left until the students have gained sufficient knowledge of the subject so that an explanation so involved will not frighten and discourage them. In introducing the table, the simple facts that magnesium reacts more readily than zinc or iron and that magnesium may displace either from solution may be demonstrated. The displacement of copper by iron, silver by copper, etc., will point out to the students the scheme of arrangement without confusing them. Attention should of course be called to the position of the elements in the series. Demonstrate the facts that silver does not displace copper, copper will not displace iron, etc. The students will come to the general conclusion that the elements standing high in the series are more active than those that follow and that each metal can displace from solution any metal lower in the series.

Questions may be asked as to how the compounds of active metals would compare in stability to the compounds of the less active metals. Would it be simple or difficult to decompose such compounds? What are the metals whose compounds are stable? Would an active metal probably remain uncombined? Hydrogen is considered as a metal. What metals will free hydrogen when acting on acids? What metals could not displace hydrogen? Why? Such questions asked and their answers properly demonstrated will give the students an idea of the utility of the series and confidence in its use.

It is a matter of opinion as to when the table should be introduced for classwork. Textbook authors differ, some placing it early and others late. From the general utility of the table it would seem practical to use it early, even with the chapter on oxygen. The usual practice of preparing oxygen by the decomposition of mercuric oxide might readily lead to the question of whether other simple oxides might not be used for the same purpose. Demonstration will show that no other simple oxide can be substituted for mercuric oxide in this preparation. The class will naturally want to know the reason for this. Question the class in the following manner. From the position of mercury in the series would you expect its compounds to be stable? Would oxides of the elements above mercury decompose as readily? Would the more active metals probably remain free at high temperatures? The questions willl be answered by reference to the series.

Oxygen may also be prepared by the decomposition of potassium or sodium chlorate. Most manuals specify these chlorates but one at least simply says that oxygen is prepared by the decomposition of a chlorate. The fact that other chlorates should not be used may be shown by the calculation of the volume of oxygen contained in a given weight of potassium chlorate and the pressure that would be exerted by its instantaneous liberation. Question the class as to the effects of this great pressure. Does potassium or sodium chlorate liberate oxygen rapidly? Would you expect it to do so? Would chlorates of metals lower in the series decompose more readily? Demonstrate the danger of using any but potassium or sodium chlorate by warming a small amount of barium chlorate (which has been moistened with sulfuric acid). An explosion is the result. This further encourages the student to use the table and to use general principles in his reasoning about chemistry.

If the series is not made use of in the chapter on oxygen, it surely should be introduced in the chapter dealing with the preparation of hydrogen. The class must understand the relative activities of the metals. The more active metals such as potassium, sodium, and calcium react with water, which is very slightly ionized, liberating hydrogen in large volumes and producing so much heat that the hydrogen may take fire. What would be the result of using these metals with a highly ionized acid? A demonstration of the activity of potassium and sodium with water will make the point clear that the action is too rapid to be controlled. What metals shall be used then? The student will naturally refer to the table and decide on a less active one such as zinc or iron. Demonstrate the preparation using the metals that the class decides on. Good results following their prediction will give them a sense of mastery and confidence in the series.

A study of the metals will lead to the question of why some metals occur free and others are always in combination. Sodium never occurs free. Sodium is an active metal. Sodium reacts with water. Would you expect it to occur free after considering its position in the table? What other metals do you think would never occur free? Why? What metals might occur either in combination or free? What metals would be most apt to occur free? How did the Forty-niners recover gold? Did they use complicated chemical processes? The displacement series will again be useful in answering these questions.

In a study of the metallurgical processes, the series serves well. Since it is impossible to consider the metallurgy of all the metals, the table is useful in pointing out the similarity of processes for obtaining similarly active metals. Generally, a description of the metallurgy of sodium is given in the text, little if anything being said of the processes for obtaining potassium, calcium, or magnesium. These metals just mentioned are active metals. Their compounds are firm. Energy is necessary to cause

decomposition. The more stable the compound the more energy necessary. What are the forms of energy? Which shall we use in obtaining these metals? Have these metals ever been obtained in any other way? How is aluminum obtained from its ore? The students get the general idea that the active metals are obtained by electrolysis.

Zinc, iron, tin, and lead are less active and are obtained by reduction of the ores, sometimes using a reducing agent such as carbon and sometimes mixing two ores which when heated are each reduced by the other. In what cases would reducing agents be used? Why? How does the treatment for gold differ from the treatment for iron? Why is there this difference?

The relation of energy to chemical change is a topic neglected by most authors. A single short paragraph is usually the only mention of energy. Yet no chemical reaction takes place without involving energy. Direct combination takes place with the liberation of energy. The energy, liberated as heat, is called the heat of formation of the compound. Active metals enter into direct combinations yielding large amounts of energy. The more energy liberated the more easily the metal combines. By knowing the position of the metals in the displacement series the student may reason about the stability of compounds and the abilities of metals to enter into direct combinations.

In teaching the replacement type of chemical reaction the teacher may again recall the series. The students should understand that the elements high in the series form compounds whose heats of formation are greater than the compounds of metals lower in the series. Aluminum oxide has a heat of formation of 392,600 calories. Ferric oxide has a heat of formation of 195,600 calories. If chemical action between aluminum and ferric oxide is started, the aluminum reduces the ferric oxide yielding free iron and 197,000 calories of heat. This heat is sufficient to melt the iron at once. This reaction may easily be demonstrated and is so spectacular that a lasting impression is made on the students' minds. The real explanation of the reaction is best made in terms of the displacement series.

The displacing power of the metals according to their positions in the series is more clearly shown by immersing clean metallic strips in various salt solutions. Strips of zinc in solutions of iron, copper, mercury, lead, and silver salts, displace those metals. Iron strips in zinc, copper, lead, mercury, and silver salts displace all metals except zinc. Repeating with lead and copper strips, the teacher can show that metals will displace from solution only the metals that follow in the series. This is the general conclusion that the students must draw from the experiment, the conclusion being arrived at by demonstration and a study of the displacement series.

Electro-plating is another process that may be clarified by the use of the

displacement series. The student will probably recognize that the process is very similar to that used for producing sodium hydroxide and will no doubt wonder why in one case sodium hydroxide is obtained and in the other the cathode is simply coated with the metal deposited from the solution. It must be pointed out that sodium is an active metal occurring high in the series whereas the metals used in plating are much less active and therefore will not react with water to form the hydroxide, nickel, copper, silver, and gold being examples of such metals. The point should be made that sodium also is deposited at the cathode but, being so active, reacts with the water present in the solution. The purpose of plating metals can also be made clear when the inactivity of the metals used for plating is understood.

In studying the electric cell it should be made clear that its electrical energy is a result of chemical activity. The cell consists of two electrodes in an electrolyte. By demonstration it should be shown that if the electrodes are of the same material no current flows. The voltage of a cell, the cause of the flow, is the result of a difference in activity between the two electrodes. By immersing electrodes of different metals into the electrolyte the pressure may be detected with a voltmeter. A different combination of electrodes will show a different pressure. What is the reason for this? The displacement series will show that a greater or less difference in activity exists in this second case than in the first. Volta's original cell contained zinc and copper electrodes and its voltage was 1.1. The zinc and carbon cell that is so commonly used today has a voltage of 1.5. What must be the chemical activity of copper compared to carbon? How could a cell of even greater activity be made? Why, if such a cell is possible, is it not in use? Why is the zinc and carbon cell the popular one? A study of the positions of the metals in the table will lead to the answers. The fact that a cell of given electrodes and electrolyte has a constant voltage, no matter what its size, is explained by the fact that the chemical activity of the electrodes is the same, regardless of size, and that the voltage, which is the result of a difference of activity, can therefore not change.

The displacement series is, of course, not the only general principle that the teacher has at his disposal and this paper does not list all of the cases in which it may be of service. It is believed however, and enough cases have been demonstrated to show, that this series is one of the most important principles and that by greater use of it the work of the teacher will be much simplified. It would seem practical to insist that the table be learned by heart and that the student be thoroughly drilled in its use. The number of elements placed in the table is a matter for the teacher to decide but the table learned should include all the common metals, and the more the merrier.

OVERHEAD PROCESS PIPING IN CHEMICAL LABORATORIES*

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Complete overhead process piping in a chemical laboratory, which is believed to be unique in so far as college chemistry buildings are concerned, has been installed in Venable Laboratories, University of North Carolina, Chapel Hill, N. C., according to the design of the author.

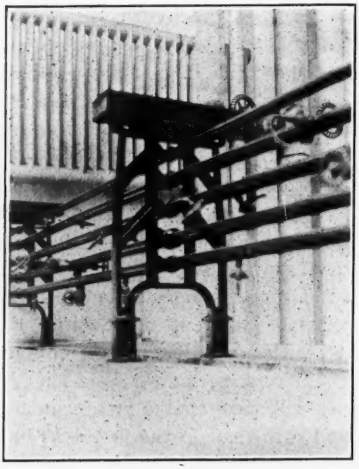


FIG. 1.—A close-up view of the arrangement of the vertical-in-line, over-the-trough piping, showing the metal pipe supports, five process lines, viz., water, steam, gas, air, and electricity—and the special drilled-in fittings.

By process piping is meant the water, steam, gas, air, chemical gases, and electrical power piping that is brought to the students' desks. The various methods by which such piping can be brought to the student are: (1) At the front of the desk below the front ledge; (2) at the rear of the desk through the desk-top; (3) at the side of the student through the desk-top; (4) at the rear of the desk from pipes supported above the desk level. The last type is generally accepted as the best for general laboratories because it embodies the following points, viz.: (*a*) Out of the way, but readily accessible; (*b*)

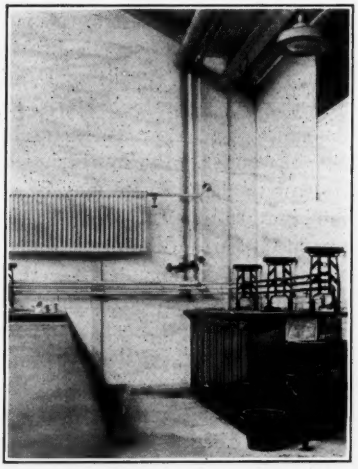


FIG. 2.—A control corner in one of the general chemistry laboratories. The risers from the main feed lines supported by the cross members of the bay, the control valves, the distribution to the set of desks and to each desk are well illustrated. The dead end of this desk alley, duplicated throughout the building, illustrates the cleanliness resulting from removal of pipes from the floor. The hanging of radiators and radiator piping above the student service lines is also well illustrated.

* Paper delivered before the Division of Chemical Education at the 74th Meeting of the American Chemical Society at Detroit, Mich., September 7, 1927.

service to two sides of a desk with a minimum amount of piping; (*c*) multiple services with no loss of desk space; (*d*) no additional equipment to take care of liquid leakage.

Piping through the desks or arrangement underneath the troughs back of the desks involves an increased cost of laboratory furniture, loss in cupboard space, inaccessibility for repairing, and inconvenience due to leakage onto floors. Elimination of such systems of piping is not as common as one would be led to expect, especially with its many disadvantages. Sectional desks, removable units, repair panels, and such types of special laboratory furniture involve added expense with no real remedy for the problem.

The arrangement of the pipes above the desk, above the trough, and along the entire length in the center of the desk seems to have all the essential

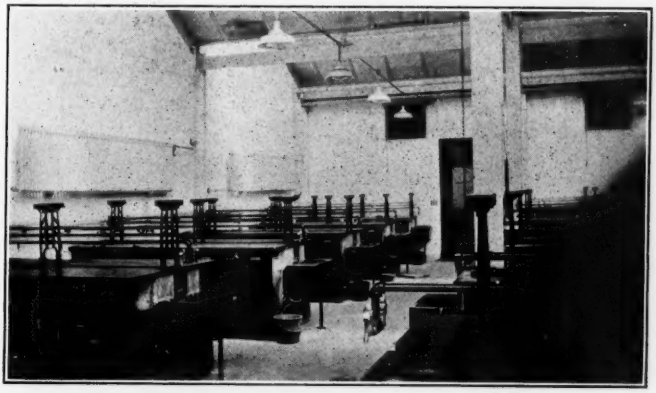


FIG. 3.—A general view of a general chemistry laboratory. Desk distribution and arrangement of the laboratory equipment are illustrated. Note the main feed lines passing across the room in the far corner of the room near the ceiling.

qualities of good piping service to the students. The feed lines to these service pipes are variously located, usually coming up from the floor or troughs in the floor. Such systems involve special floor construction and hidden piping, in many instances requiring tearing up of flooring to get at the piping. Repairs of this type are costly and inconvenient, usually left until the inconvenience occasioned by misuse or leakage necessitates major repairs.

One hundred per cent visible piping is new; the placement of such piping entirely above the desk level and without special pipe hangers is unique. Such a system of piping was possible and was installed in our laboratories. The piping starts from a central location, rising to the seventeen-foot

level in the saw-tooth structure housing the general laboratories. From this point the main feed lines supported on the cross-members of the bays of the saw-tooth roofs branch off to different parts of the building. In one corner of each room risers are dropped down the wall to the level of the specific piping for the desks. From this point the laboratory feed lines pass along the wall, the desk service lines branching off at the wall-end of each set of desks. Air, gas, steam, water, hydrogen sulfide, and electricity are thus distributed to each student. No pipe hangers, with the exception of lugs in the metal pipe standards on the desks, were used. The metal pipe standards and lugs were of special construction purchased

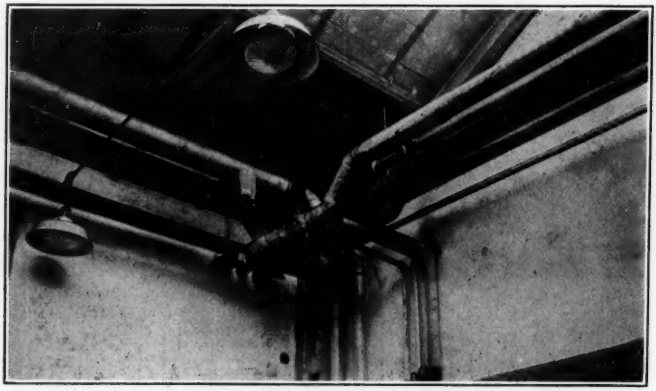


FIG. 4.—The master control system in a corner of the quantitative laboratory.

through the Walrus Manufacturing Company of Decatur, Illinois. Some views of the laboratories in Venable Hall give illustrations of the overhead piping installations.

The blocks on all the metal uprights shown in the views were placed there in anticipation of the installation of the D-V fume elimination system.[1]

The above system does away with all piping near the floor with no hidden places to throw trash. The service cocks at the desks, being at the lowest points in each piping system, serve as drip-cocks. All leaks are readily visible. Extra unions were placed in the lines to enable easy repair and removal of any section. Each desk service line is readily removed by release of the pipe lugs and turning out the pipe.

[1] Described in THIS JOURNAL, 5, 589–94 (May, 1928).

A MODIFICATION OF THE PYROGALLOL METHOD FOR DETERMINING THE AMOUNT OF OXYGEN IN THE AIR

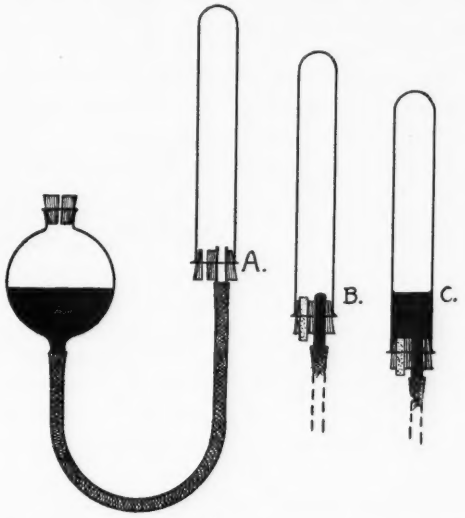
L. A. MUNRO, AGRICULTURAL COLLEGE, UNIVERSITY OF MANITOBA, WINNIPEG, CANADA

The pyrogallol method for determining the percentage of oxygen (by volume) in the air, described by Foster in THIS JOURNAL, **4,** 638–9 (May, 1927), has been used in the first-year laboratory of this department for several years.

A modification of the above method has been found to possess certain advantages. The past session has shown it to be more rapid, to give better results, and to be cleaner in manipulation than the old method.

The Modified Method

The apparatus consists of a test tube 8″ x 1″ fitted with a two-hole stopper, glass plug, and glass tube, connected to a leveling bulb by a section of rubber tubing. A fluted cork fits loosely into the top of the bulb.



The apparatus is first set up as shown in the diagram, the inverted test tube with the plug removed being supported by a clamp and the bulb by a retort ring. At the start, the level of the stopper is above the level of the centre of the bulb (*A*). The alkaline pyrogallol (30 cc.) is next prepared and immediately poured into the bulb and the fluted cork inserted. The test tube is now lowered by means of the clamp until the pyrogallol appears at the end of the tube at (*B*). The glass plug is then

inserted and the tube lowered further. This forces some pyrogallol into the tube and hastens the reaction. The level of the stopper is marked with gummed paper.

When an interval of ten minutes shows no further rise in level of the liquid in the tube, the bulb and tube are brought to the same level (*C*). The level of the liquid is marked with gummed paper and the percentage of oxygen calculated in the usual way.

Advantages

In the old method, the tube which projects through the stopper was filled by opening the pinchcock, allowing the liquid to flow through the tube and then closing the pinchcock. The stopper was then inserted in the test tube. Filling the tube is accomplished more conveniently and without soiling the hands, by the modified method.

This method is also more rapid. The use of a bulb with a loose-fitting cork, in place of the open funnel, is an advantage. As the oxygen in the bulb is absorbed, the bulb soon becomes filled with nitrogen (except for the small amount of oxygen admitted by diffusion). The pyrogallol is therefore kept active and the determination is consequently more rapid.

It has not been the experience of the writer that a determination can be made "in a few minutes," by either method.

More accurate results have in general been obtained by the students using this method. This is probably due to the fact that with the inverted test tube, the occasional leaks occurring around the glass plug, rubber stopper, etc., are eliminated as a source of error, for the pyrogallol on entering the inverted tube "seals" any leaks without changing the volume or the pressure of the enclosed air. With the old method, a slight leak, unnoticed by the student, resulted in a high result due to the escape of air and its replacement by the pyrogallol. Sometimes also, an error was introduced by the escape of a bubble of air through the vertical tube owing to temperature changes. This is eliminated in the modified method.

The leveling bulbs were made by our technician from ordinary soft glass 150 cc. flasks.

The use of dropping-funnels is not recommended.

W. D. Harkins, Willard Gibbs Medalist. W. D. Harkins, professor of physical chemistry at the University of Chicago, has been chosen as the recipient of the Willard Gibbs Medal for 1928. The award was made on May 25th at the regular meeting of the Chicago Section.

Dr. Harkins is particularly known for his researches on isotopes and atomic structure.

HOW ARE TEACHERS BEING TRAINED IN COLLEGE FOR TEACHING HIGH-SCHOOL CHEMISTRY?*

It is now coming to be recognized[1, 2, 3] that the well-trained high-school teacher of chemistry, or indeed of any other field of science, should possess: (1) a thorough knowledge of the fundamentals of the subject; (2) some training in the allied branches of science and a clear understanding of the interrelationships between these sciences; (3) some definite training in the presentation of the subject and a clear conception of what results are to be accomplished in the teaching of chemistry, which of course implies (4) an understanding of the pupil and of modern society. It is the purpose of this committee to show to what extent these fundamental requisites find a place in the programs for the training of chemistry teachers in this country.

In dealing with this problem, one thinks first, perhaps, of the so-called "methods courses" which have rapidly appeared in the curricula of our institutions in the past few years. Miss Hayden[4] made a careful survey of this question. She sent questionnaires to all of the schools and colleges which listed "science methods courses" in their catalogs (one hundred-fifty in all). The names of these institutions were determined from a preliminary examination of the 1924–5 catalogs of two hundred seventy-five "class A" colleges and universities, and two hundred normal schools and state teachers' colleges. The survey, therefore, may be regarded as complete so far as the number of institutions is concerned. Unfortunately, only ninety-seven or approximately 65 per cent of the one hundred fifty questionnaires were returned. Seventy-one of these institutions were offering courses in the methods of teaching chemistry or physical sciences, including chemistry.

Miss Hayden has also summarized the general content of the "methods courses" in so far as they were outlined in her questionnaire. Currier[5] has prepared an outline of the topics covered in a course given in one state institution.

Such courses include the following topics:

(1) A history of the teaching of chemistry; (2) the status and objectives

* Committee report, submitted to the Senate of Chemical Education of the A. C. S. at St. Louis, April 16, 1928.

[1] "The Training of Chemistry Teachers—Prospective and in Service," Hopkins, *Sch. Sci. Math.*, **25**, 233 (1925).

[2] "The Training of High-School Chemistry Teachers," Currier, THIS JOURNAL, **3**, 701–3 (June, 1926).

[3] "The Training of Teachers—The Problem of Professionalized Subject Matter," Fries, *J. Educ. Admin. & Superv.*, **13**, 178 (1927).

[4] THIS JOURNAL, **3**, 528–32 (May, 1926).

[5] *Loc. cit.*

of high-school chemistry; (3) a review of the subject-matter from the standpoint of (*a*) the technic of presentation, (*b*) historical and theoretical background; (4) correlation of lecture and laboratory work, lesson planning, examinations, notebooks, projects, library work, etc.; (5) laboratory equipment and maintenance; (6) professional advancement of the teacher and his relations in the school and community including a discussion of public exhibits, analytical or consultation work, night schools, etc.

With reference to the "methods courses" there appears to be a very wide variety of opinion. The answers to Miss Hayden's questionnaires contain many personal statements which reflect attitudes of bitter sarcasm and resentment, on the one hand, and great interest and encouragement on the other. Perhaps some of the prejudice which appears in some quarters could be overcome if these courses could be relabeled, "Teacher's Courses in Chemistry" or "The Teaching of Chemistry." These courses should be taught in all cases by individuals who are thoroughly trained in chemistry and who have some appreciation of the interrelations of other sciences[6] with chemistry and realize what the problem of the high-school chemistry teacher is, preferably from actual experience in secondary school teaching. Indeed, the committee feels that if this latter need could be met in all institutions which attempt to train teachers, we would have taken a long step in the way of supplying better chemistry teachers.

> There is undoubtedly a firm conviction on the part of many teachers that subject-matter and methods must be separated, the latter following the former in every case. According to this point of view, an attempt to do the two things at once is to incur the risk of divided attention, with the probability that neither will be done well. This is, of course, a danger to be avoided. It is probable, however, that those who take this view have an exaggerated idea of what "method" is. Mastery of method in a given material is, after all, little more than a clear consciousness of the way in which the material shapes itself most advantageously to the learner.[7]

The amount of work in chemistry which is required for teachers in the institutions represented in the survey conducted by Miss Hayden[8] is summarized as follows:

> The prerequisites in chemistry vary from no work at all to sufficient work to permit of graduate standing in the department. These courses include general, analytical, organic, and in a very few instances, physical chemistry.

A detailed statement of courses recommended for chemistry teachers at one of the leading eastern universities may be of interest. The courses are as follows:

General Chemistry (one year), Qualitative Analysis (one-half year), Quantitative Analysis (one-half year), Organic Chemistry (one year),

[6] J. C. Hessler, *Sch. Sci. Math.*, **17**, 511 (1917).

[7] *Bulletin No.* **14**, Carnegie Foundation for the Advancement of Teaching, p. 231.

[8] *Loc. cit.*

Physical Chemistry (one year), History of Chemistry (one-half year), Educational Psychology (one-half year), Educational Measurements (one-half year), Principles and Practice in Teaching (one year), Special Methods in Science Teaching (one-half year).

How much work in educational subjects should be required is a much debated question at the present time. There are those who would include no work of this nature in the curriculum for chemistry teachers. Others appear to place an undue emphasis upon educational subjects.

> The prerequisites in education vary from no work to thirty-six hours. This includes general and educational psychology and principles of education in the large majority of cases..... Only five schools are offering methods courses which are under the direction of men in the department of education.[9]

It should be noted that these latter institutions are among our largest and well-known universities. The courses are given as "Teaching of Science" and are in charge of science teachers or supervisors who work in the practice schools, usually known as "University High Schools." The instructors are in most of these cases connected with the department of education. This arrangement probably represents our best efforts in teacher training for two reasons: (1) the prospective teacher gains practical experience in teaching under expert supervision, and (2) the interrelationships of the other sciences are recognized. (It will be shown later in the report that the majority of teachers are required to teach other sciences besides chemistry.)

Perhaps the most important part of the whole program of training for chemistry teachers and the part which is most difficult to provide is practical teaching under competent supervision. The survey previously referred to, showed that sixteen institutions included practice teaching in their courses. This number will probably be increased in the future.

Several studies[10, 11, 12, 13] have been made in which the work done in college is compared to the work followed after leaving college. These studies show that the universities train "specialists" and the high schools use "generalists." "Specialist" refers to those trained relatively well along one line of science but have little or no training in related fields. "Generalists" refers to those who have had fundamental courses in several of the basic sciences but who are not highly specialized in any one branch. "Specialists" are fitted to teach in large schools where one teacher has

[9] *Loc. cit.*

[10] H. W. Josselyn, "Survey of Accredited High Schools and Professional Directory," *Univ. of Kansas Bulletin*, Vol. **15**, 16, 88 (1914).

[11] P. W. Hutson, *Educ. Admin. & Superv.*, **9**, 423–38 (1923).

[12] S. R. Powers, *Gen. Sci. Quart.*, **8**, 481–97 (1924).

[13] C. W. Finley, "Biology in Secondary Schools and the Training of Biology Teachers," pp. 33–68.

classes in one subject only. Frank[14] states that only 7 per cent of all chemistry teachers are responsible for the teaching of chemistry alone, and that only 1 per cent of the schools give more than one year of chemistry.

In general, small colleges are fulfilling the needs of the "generalists" better than the larger colleges, because the small colleges do not have facilities which permit of specialization to any great extent.

Hutson[15] points out some interesting facts in an analysis of an investigation of the training and teaching programs of the teachers in the State of Minnesota. In this survey, replies were received from 1134 teachers or about one-third of the teachers of the state. The questionnaires of 270 teachers who reported one or more classes in science were isolated for special study. These science teachers were trained in 58 different institutions located in 17 states and Canada. The following data, therefore, would seem to indicate the general situation:

TABLE I

The teachers were classified as follows:

	Number of teachers
Group I (faculties of 30 or more)	43
Group II (faculties of 11–29 inclusive)	58
Group III (faculties of 10 or fewer)	106
Group IV (high-school departments of state graded schools)	63
Total	270

TABLE II

PERCENTAGE DISTRIBUTION OF SCIENCE TEACHERS ACCORDING TO THE NUMBER OF SCIENCES IN WHICH THEY HAVE TAKEN 12 OR MORE HOURS

Number of sciences	Group I (37)	Group II (56)	Group III (101)	Group IV (58)	All groups (252)*
0	24.3	32.4	35.6	37.9	33.8
1	43.2	48.6	43.6	52.0	46.5
2	21.6	18.0	16.8	6.9	15.5
3	10.8	1.8	3.0	1.7	3.6
4	..	..	1.0	1.7	0.8

* The total number 252 does not agree with that in I on account of the fact that the questionnaires were incomplete in some details.

There is not space for a detailed analysis of this survey. A careful study of the tables, however, leads one to conclude that the situation is far from ideal and, as Hutson points out, "the evidence points also to the desirability of a more intensive study of the problem of affording the teacher-in-training, proper arrangement of content courses."[16]

[14] Frank, "The Teaching of First Year Chemistry," J. O. Frank, Oshkosh, Wisconsin, 1927, p. 7.

[15] *Loc. cit.*, pp. 424–7.

[16] *Loc. cit.*, p. 438.

TABLE III

PERCENTAGE DISTRIBUTION OF THE TEACHERS OF SCIENCE ACCORDING TO THE NUMBER OF SUBJECTS THEY TEACH

Number of different subjects	Group I (43)	Group II (58)	Group III (106)	Group IV (63)
1	39.5	8.6	0.0	0.0
2	32.6	32.8	28.3	11.1
3	25.6	37.9	33.0	25.4
4	..	17.2	30.2	30.2
5	2.3	1.7	4.7	25.4
6	..	1.7	2.8	6.3
7	..	..	0.9	1.6
Totals	100.0	99.9	99.9	100.0

Summary

1. The fundamental principles in the training of high-school chemistry teachers have been outlined. It has been shown also to what extent these principles are incorporated in the curricula of our colleges and universities. A brief statement is made of specific courses given in one leading institution.

2. Evidence is given to show that the majority of chemistry teachers must also teach other sciences. Other sciences should therefore be included in the program of teacher training.

3. Our leading universities are providing facilities for practice teaching under expert supervision.

A. J. CURRIER, *Chairman*
HENRIETTA HAYDEN
N. HENRY BLACK
A. E. MCKINNEY

THE PROFESSIONAL SPIRIT AMONG HIGH-SCHOOL CHEMISTRY TEACHERS*

The members of the committee appointed by the Division of Chemical Education of the American Chemical Society, "To Seek to Arouse a Professional Spirit among High-School Chemistry Teachers as a Group" have each discussed and contributed to the following report. The Committee considers this a preliminary report and requests that members of the Division of Chemical Education and of the American Chemical Society think upon the possibilities of the work assigned to this Committee, which concerns not only high-school chemistry teachers but all other teachers of chemistry, and send suggestions to any member of this Committee.

In view of the awakening of the public conscience to the importance of

* Committee report, submitted to the Senate of Chemical Education of the A. C. S. at St. Louis, April 16, 1928.

chemistry and its great ramification throughout the fields of higher education, an unusual opportunity exists for a more general recognition of chemistry as a basic subject for those who wish to obtain the fullest advantage of college training. To meet this challenge it is imperative that the professional spirit of high-school teachers of chemistry be properly nourished.

Some of the difficulties in this endeavor are: short tenure, inadequate pay, a teaching schedule in which chemistry is sometimes minimized, many cases in which science teachers are responsible for more than one subject, often incomplete equipment for experimental work, and too often the selection of teachers to teach chemistry who are not primarily interested in chemistry.

Shall not the power of the Division of Chemical Education and of the American Chemical Society operate to lessen these difficulties and strive to help nourish the spirit of the high-school teachers of chemistry who touch the lives of many that may never again have an opportunity to study chemistry and, also, leave the imprint of their training on the minds of those that enter college? "Coats off" for the spirit of those who rock the cradle of chemistry and thereby help to move the world onward, for there are still a great many people who do not seem to realize the basic significance of chemistry to an advancing civilization.

To that end all teachers of chemistry should subscribe to the JOURNAL OF CHEMICAL EDUCATION for the following reasons: First, the editorial policy is exclusively under the control of the Division of Chemical Education of the American Chemical Society and the personnel of this Division is characterized by the very highest types of professional spirit specializing in chemical education; and secondly, the editorial staff and six departmental editors, and fifty-eight contributing editors seek diligently and intelligently to lift the essential problems bearing on chemical education into the clear consciousness of chemistry teachers, to present the best of what has been accomplished in the solution of such problems, and to make the JOURNAL a forum cordially opened for the solution of these problems and for the statement of new ones.

Since the press is a recognized power in any movement why not use our JOURNAL OF CHEMICAL EDUCATION? Suggestion! Please send the name of that high-school teacher of chemistry whom you know personally, to Mr. Wm. W. Buffum, Business Manager, JOURNAL OF CHEMICAL EDUCATION, 85 Beaver Street, New York, N. Y., with the request that a copy of the JOURNAL be mailed to your high-school friend and follow this with a letter to your friend stating what you have done. Why not also do that for some other friend in the glorious company of chemistry teachers?

Again every teacher of chemistry should be affiliated with some educational organization devoted to the furthering of efficiency in the teaching

of chemistry and in the diffusion of knowledge pertaining to chemistry. To that end membership in the American Chemical Society is urged. Its semi-annual meetings, the monthly meetings of its local sections throughout the United States, its summer Institutes, and the various nation-wide associations of chemistry teachers under other control but strongly influenced by the same society make it within the range of all teachers of chemistry to come in touch personally with the dynamic inspiration of such meetings.

Another suggestion! Please send the name of that friend, who should be a member of the American Chemical Society to the secretary of that organization with the request that a blank for membership with the circular of information about the Society be mailed to that friend and follow that up with a letter to your friend stating what you have done.

Why not be an active missionary in a good cause?

LOUIS W. MATTERN, *Chairman*
CHARLES H. STONE
HAL WALTERS MOSELEY
M. CANNON SNEED
JOHN FULTON

MINIMUM EQUIPMENT FOR HIGH-SCHOOL CHEMISTRY*

This committee was appointed about April 23, 1926, and originally consisted of the following members:

L. W. Mattern, *Chairman;* McKinley Training High School, Washington, D. C.

R. H. Price, Phillips High School, Birmingham, Ala.

J. H. Norton, Junior College, Sacramento, California

J. P. McDermott, West High School, Weston, Va.

J. H. Jensen, Northern Normal, Aberdeen, S. Dak.

Professors Price and McDermott requested that they be excused from work on this committee as they are no longer engaged in school work. At the Philadelphia meeting Professor Mattern asked to be excused on account of other work. Hence, the present committee consists of Professor Norton and the chairman. It has been rather difficult to carry on this work, but with the reorganization of the committee we hope to make more rapid progress.

A preliminary report of the committee was made at Philadelphia based on a study of some 30 available lists of minimum equipment for high-school chemistry as issued by the 30 state departments of education.

* Committee report, submitted to the Senate of Chemical Education of the A. C. S. at St. Louis, April 16, 1928.

The cost of individual equipment, general apparatus, and chemicals for a class of 8 pupils varied from 138 dollars to as high as 487 dollars (the average cost per pupil being about 3.35 dollars).

At that time the committee was instructed to make up a list of equipment, stating the cost of renewal and length of life of each item. The committee attempted to secure this data by means of a questionnaire sent to the members of the Senate of Chemical Education. Out of a total of 100 sent out 28 considered the work worthwhile and spent some time in giving some very valuable suggestions.

A tentative list was presented at the Richmond meeting but no action was taken on the same. Also, a report was presented at the Detroit meeting indicating progress in the work. It is hoped that some definite action will be taken on this much of the report in order that the committee may know the wishes of the Division of Chemical Education.

In this tentative list the committee is presenting only the equipment for the individual pupil and such apparatus that may be used in common by two pupils. Each item is carefully specified as to size, type, and grade; as 250 cc. Beaker, Pyrex, low form. Such specifications are necessary for the inexperienced teachers in the high schools with an enrolment of 150 or less. This group of high schools makes up 74% of the total number of high schools in the United States. Also if the lists are submitted for bids each supply company will of necessity have to bid on exactly the same item.

The third project undertaken by this committee was to write to the state high-school inspector of the various states in order to find out if such a list of minimum equipment would be desirable. 33 of these inspectors stated that such a list would be desirable and the reasons stated are as follows:

1. To prevent foolish buying of equipment by inexperienced teachers.
2. Aid schools to secure necessary equipment.
3. Would show a definite requirement.
4. If state department allowed credit for chemistry without equipment specified some school boards would never buy any equipment.
5. School authorities do not know what is necessary.
6. Set up definite standards.
7. Result in economy in buying of equipment.
8. Because our principals and science teachers are dependent largely upon lists furnished by supply companies whose interest is not the needs of the pupil, but in the sales made.
9. Even trained teachers need guidance badly. Representatives of apparatus supply houses do not show sound judgment in their recommendations.
10. Boards of education do not realize the necessity of providing equipment and often furnish inferior equipment.

11. Without minimum equipment lists, equipment would be inadequate in 75% of the schools.

12. To secure uniform standards as a basis for accrediting.

Further, an examination of the state lists now available shows the need of a more standardized list. For instance, taking the items of beakers as a sample we find the following:

For a class of 8 pupils the state lists require the following:

1 state requires	4 beakers, 100 cc. for 8 pupils
26 states require	8 beakers, 100 cc. for 8 pupils
1 state requires	16 beakers, 100 cc. for 8 pupils
3 states require	4 beakers, 250 cc. for 8 pupils
19 states require	8 beakers, 250 cc. for 8 pupils
3 states require	16 beakers, 250 cc. for 8 pupils
1 state requires	4 beakers, 150 cc. for 8 pupils
6 states require	8 beakers, 150 cc. for 8 pupils
2 states require	4 beakers, 400 cc. for 8 pupils
12 states require	8 beakers, 400 cc. for 8 pupils

In some cases nests of beakers from 60 cc. to 400 cc. are specified. From the standpoint of the committee it would seem that it ought to be possible to standardize on not over two sizes of beakers for student use. A similar variety of sizes and types exist for other items such as flasks, bottles, etc.

Next, the committee secured the list of equipment supplied to the students in our large city high schools for purposes of comparison with the tentative list. The more experienced teacher would be located in these schools and in most cases would have a fairly stable list of equipment worked out for his particular use.

The items listed in this report are articles that would be usually required in any type of course. The only contribution made will be that of a definite specification for each item and an attempt to standardize on sizes, types, and grades.

This list meets the requirements of the following:

1. The equipment necessary for the minimum list of experiments as prepared by the Senate of Chemical Education.

2. The equipment necessary for the individual pupil as given in the commonly used textbooks such as Brownlee and others, Black and Conant, McPherson and Henderson.

3. Only such items are included as are used sufficiently often by the pupil to warrant being placed in the pupil's desk.

In the tentative list attached, please note that this list is the apparatus for the individual pupil only and the list of items that may be used by two pupils in common. Please keep in mind that we are attempting to prepare a list for the inexperienced teachers in the small high school. Therefore, we have attempted to set down very definite specifications for each item as far as that is possible. This is necessary in order to secure a suit-

able grade of equipment and to insure the supply houses quoting on the same grade of material if the list is submitted for bids.

All items in the list have been checked so that the items are properly co-related, for instance:

3 inch ring to serve as funnel support;

Rubber corks to fit test tubes, bottles;

Evaporating dish to fit 400 cc. beaker which serves as water-bath;

Watch glass to fit 400 cc. beaker and evaporating dish.

If this tentative list meets the approval of the Division of Chemical Education then the committee's next projects will be as follows:

1. To prepare a list of general apparatus needed for use of pupils and instructor.

2. To list the chemicals necessary for the minimum list of experiments as prepared by the Division of Chemical Education, specifying in each case the grade of chemical needed such as Commercial, Technical, U. S. P., or C.P. To determine the grade most economical to buy and to determine the number of students it may reasonably be expected to serve.

3. To make up an additional list of material so it will be possible to work a greater variety of experiments.

4. To make up a list of desirable demonstration equipment for the use of the instructor.

Minimum Equipment for H.-S. Chemistry

INDIVIDUAL APPARATUS

For a class of 8 pupils or for 16 working in groups of twos

	Unit price	Total
8 Beakers, Griffin low form, with lip, Pyrex (resistance grade at 0.17) 250 cc.	$ .25	$ 2.00
8 Beakers, Griffin, low form, with lip, Pyrex (resistance grade at 0.20) 400 cc.	.36	2.40
32 Bottles, wide mouth, white glass, uniform neck, 4-ounce	.09	2.88
32 Rubber stoppers to fit 4-oz. wide mouth bottles no. 6, 2-hole, sp. gr. 1.2 to 1.4	.07	2.24
2 Bundles of Splints (500 in bundle)	.10	.20
8 Calcium Chloride Tubes, U-shape, plain 6-inch	.20	1.60
16 Rubber stoppers No. 1, to fit tubes, one hole, sp. gr. 1.2–1.4	.03	.48
8 Crucibles with covers, Coors, low form, no. 00	.18	1.44
8 Dishes, evaporating, Coors, 75 mm. dia., no. 00-A	.25	2.00
8 Pkgs. Filter Paper, 12½ cm. dia.	.16	1.28
8 Flasks, flat bottom, Erlenmeyer form, Pyrex, 250 cc.	.20	1.60
8 Rubber Stoppers to fit 250 cc. flask, two-hole, no. 6, sp. gr. 1.2–1.4	.07	.56
8 Funnels, short stem, 65 mm. dia.	.25	2.00
8 Funnel Tubes like Central Scientific no. 6192A	.15	1.20
32 Glass Plates, 10 × 10 cm. (secure locally) (use wet filter paper instead of glass plates as covers)		

8 Graduates, cylindrical, graduated 1 cc., 50 cc. size, Exax grade	.65	5.20
16 Vials Litmus Paper, 100 strips per vial (8 vials of red and 8 vials of blue)	.10	1.60
8 Pinch clamps, Hoffman, screw compression, small	.25	2.00
8 Pipestem Triangles, 2 inch inside	.10	.80
8 Doz. Test Tubes, machine made, well annealed, 6 × 3/4 inch	.35 doz.	2.80
8 Test Tubes, Pyrex, 25 × 200 mm. (may be used as gas generators instead of 250-cc. Erlenmeyer flasks)	.25	2.00
8 Rubber Stoppers to fit pyrex test tube, 2-hole, no. 5	.06	.48
8 Test-Tube Brushes, tinned iron, tufted end	.07	.56
8 Test-Tube Clamps, Stoddard form, brass	.12	.96
8 Thermometers, −10 to 110 degrees, engraved scale, solid stem, graduated in one degree div.	1.10	8.80
8 Watch Glasses, to fit evap. dish and 400 cc. beaker, 3 1/2 in. diam.	.10	.80
Total		$47.88

DESK APPARATUS

(Equipment that may be used in common by two pupils or two classes)

8 Alcohol Lamps, 8 oz. (where gas is not available)	.40	3.20
8 Bottles, Reagent, name in glass, Hydrochloric Acid, 40 oz., glass stoppered, narrow mouth	.20	1.60
8 Bottles, Reagent, name in glass, Sulphuric Acid, 4 oz., glass stoppered, narrow mouth	.20	1.60
8 Bottles, Reagent, name in glass, Nitric Acid, 4 oz., glass stoppered, narrow mouth	.20	1.60
8 Bottles, Reagent, name in glass, Sodium Hydroxide, 4 oz., rubber stoppered, narrow mouth	.20	1.60
8 Bottles, Reagent, name in glass, Ammonium Hydroxide, 4 oz., rubber stoppered, narrow mouth	.20	1.60
8 Burette Clamps, with clamp attached	.55	4.40
8 Deflagrating Spoons, 3/4-inch cup, brass	.13	1.04
8 Files, Triangular 5 inch	.10	.80
8 Mortar and Pestles, porcelain, Coors, 100 mm. dia.	.70	5.60
8 Pneumatic Troughs (may use stew pans or make locally)	.65	5.20
8 Ringstands, iron, base 5 × 8 inches, rod 20 × 3/8 in.	.60	4.80
8 Rings, iron with clamp attached, 3-inch dia. to serve as funnel support	.18	1.44
8 Rings, iron 4-in. dia. to serve as supports for beakers and evaporating dish	.20	1.60
8 Sponges (16 to lb.)	1.50 lb.	.75
8 Test Tube Racks, 10 tube wood with drying pins	.75	6.00
8 Wire Gauze, asbestos center, 20 mesh, iron, 5 × 5 inches	.12	.96
Total		$43.79

Total cost of Individual Apparatus for 8 pupils	47.88
Total Cost of Desk Apparatus for 8 pupils	43.79
Grand total	$91.67
Cost per Pupil	$11.46

If gas is available omit the alcohol lamps and add:			
8 Wing tops for Bunsen Burners		.10	.80
8 Bunsen Burners for Plaugas, Gasoline, etc.		.65	5.20
16 Ft. Rubber Tubing for burners, white cloth impression, 1/4 in. dia. for burners		.14 ft.	2.24
			8.24
Deduct for 8 Alcohol Lamps			3.20
			5.04
Grand Total	91.67		
Add Bunsen Burners	5.04		
	96.71		
Cost per pupil	12.09		

Allow about 25% for breakage of glassware
Life of glassware about two years
Renewal cost per pupil per year is about $0.50
(Prof. Carpenter of Rochester, N. Y., states the breakage fees paid by 235 pupils from January, 1925, to January, 1927, is $0.30 per pupil.)

Regular corks to fit w. m. Bottles no. 15 at $1.00 per 100	1.00	
Regular corks to fit $CaCl_2$ tubes, no. 6, at .37 per 100	.37	
Regular corks to fit 250-cc. flask, no. 14, at .80 per 100	.80	
Regular corks to fit test tube, no. 7, at .40 per 100	.40	2.57
Cork borer, set of 3	.60	
Cork borer sharpener	1.50	2.10
Cost of 400 corks plus borer and sharpener		4.67

Average cost of cork about one cent each
64 rubber stoppers total as stated in list 3.76
Average cost of rubber stoppers about six cents each (rubber stopper more convenient, no boring of holes).

Respectfully submitted to the Senate of Chemical Education of the American Chemical Society, April 16, 1928.

J. H. NORTON
J. H. JENSEN, *Chairman*, Committee on Minimum Equipment for High-School Chemistry

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Industrial research is accelerated experience.—DEL MAR

PROGRAM OF PAPERS, SIXTH COLLOID SYMPOSIUM

University of Toronto, June 14, 15, 16, 1928

1. Sir William B. Hardy, Cambridge, England. (Title not yet received.)
2. Dr. H. A. Abramson, "Cataphoresis of Blood Cells and Inert Particles in Sols and Gels and Its Biological Significance" (with motion pictures).
3. Wilder D. Bancroft and C. E. Barnett, Cornell University, "Adsorption of Methylene Blue by Lead Sulfate."
4. David R. Briggs, University of Minnesota, "Surface Conductance."
5. E. F. Burton and Beatrice Reid Deacon, University of Toronto, "Influence of Temperature on Coagulation of Colloidal Solutions."
6. John R. Fanselow, University of Wisconsin, "The Influence of Electrolytes and Non-Electrolytes upon the Optical Activity and Relative Resistance to Shear of Gelatin Systems."
7. William D. Harkins, University of Chicago, "Charges on Colloidal Particles, Adsorption, and the Spreading of Liquids."
8. A. B. Hastings, University of Chicago, "The Rôle of Hemoglobin in the Blood."
9. Ernst Hauser, Frankfurt am Main, Germany, "New Microscopic Methods in Connection with the Problem of Vulcanization."
10. Emil Heuser, International Paper Company, Ontario, "Problems of Cellulose Chemistry."
11. Harry N. Holmes and Robert C. Williams, Oberlin College, "The Uniform Distribution of Catalysts throughout Porous Solids."
12. F. B. Kondrick, University of Toronto, "The Effect of Adsorbed Water on Electrical Conductivity of Powders."
13. John C. Krantz and Neil E. Gordon, University of Maryland, "Hydrogen-Ion Concentration and Stability of Emulsions."
14. M. E. Laing, J. W. McBain, and E. W. Harrison, Stanford University, "Adsorption of Sodium Oleate at the Air-Water Interface."
15. J. W. McBain, W. F. K. Wynne-Jones, and F. H. Pollard, Stanford University, "The Activity and Adsorption of *p*-Toluidine in the Surface of Its Aqueous Solutions."
16. P. J. Moloney and Edith M. Taylor, Connaught Research Laboratories, "Fractionation of Diptheria Anti-Toxic Sera."
17. Stuart Mudd, Baludin Lucke, Morton McCutcheon, and Max Strumia, University of Pennsylvania, "Relation between Surface Properties and Phagocytosis of Bacteria."
18. H. A. Neville and H. C. Jones, Lehigh University, "The Study of Hydration Changes by a Volume-Change Method."
19. J. B. Nichols, du Pont Company, "The Development of the Ultracentrifuge and Its Field of Research."
20. Fred Olsen, Picatinny Arsenal, "Influence of Gel Structure upon the Technology of Smokeless Powder Manufacture."
21. A. J. Phillips, Picatinny Arsenal, "Structure of Cellulose Nitrate and Cellulose Nitrate Gels."
22. W. L. Robinson, University of Toronto, "The Filtration of Colloids by the Spleen."
23. S. E. Sheppard and R. H. Lambert, Eastman Kodak Company, "Grain Growth in Silver Bromide Precipitates."
24. A. J. Stamm, Forest Products Laboratories, "The Structure of Softwoods as Revealed by Dynamic Physical Methods."
25. H. L. Trumbull, B. F. Goodrich Company, "The Preparation and Properties of Rubber Dispersions."

26. Hardolph Wasteneys and H. Borsook, University of Toronto, "Emulsions and Protein Synthesis."

27. Harry B. Weiser and G. E. Cunningham, The Rice Institute, "Adsorption of Ions and the Physical Character of Precipitates" (with motion pictures).

28. G. S. Whitby, J. G. McNally, and W. Gallay, McGill University, "Studies of Organophilic Colloids."

A NOTE ON REMOVING "FROZEN" GLASS STOPPERS

JAMES C. RICE, JUNIOR COLLEGE, KANSAS CITY, MISSOURI

The forehanded teacher of chemistry always remembers to empty glass-stoppered bottles when he closes the laboratory for the summer. To such teachers this note does not apply. For those who, like the writer, sometimes fail to do this the following suggestion may prove valuable.

The stoppers of reagent bottles, particularly those containing sodium hydroxide, often freeze, especially during the summer vacation. If the bottle chances to contain a small amount of the solution the stopper can sometimes be removed by inverting and so causing the contents to act as solvent.

The writer makes it a practice to collect bottles with frozen stoppers at the beginning of school in the fall. He inverts these bottles and permits the solution to exert its solvent action on the frozen stoppers for about a week.

The method is successful in about two-thirds of the cases. In those cases in which it fails other methods are equally futile. In as much as the process is one involving "mass production" it has proved a valuable laboratory aid. Even so hopeless a case as a bottle containing sodium bisulfite of two years' standing proved amenable to the method.

German Process Separates Oil by Electricity. A process for getting oil out of steam condensation water has been developed by Fritz Hoyer, a German scientist. It is expected to replace the mechanical methods for removing the troublesome residue of oil now in use.

Most of the oil which is used for lubricating steam pistons and gearing is atomized and carried away in the waste steam. As a result of this a very stable milky emulsion is formed on the condensed water, and the problem of separation of oil and water is an extremely difficult one. Many mechanical oil separators have been tried, but up to the present they have not been an unqualified success, and when the condensed water which has passed through them is used for the boiler appreciable quantities of oil also pass in. This oil combines with the boiler scale to form a solid mass which settles on the walls of the boilers and tends to cause overheating of the plates.

In the Hoyer process a direct current is passed through the water, which collects the oil in small foam flakes, thus destroying the emulsion and making filtration possible. The consumption of electricity is about one kilowatt hour for five cubic meters of water. —*Science Service*

Correspondence

A QUESTION OF PROCEDURE

Under this title, Mr. Charles H. Stone,[1] a clever teacher of chemistry in the English High School of Boston, recommends that the time-honored procedure for computing the smallest possible molecular weight of a compound from its percentage composition be changed. Instead of first finding out how many gram atoms of an element are present in one hundred grams of the original substance and in that way finding the ratio existing between the atoms in a given weight of substance, Mr. Stone first finds the molecular weight on the basis that one atom of some element, chosen at random, is present in the molecule. Thus if a substance contains 43.4% of sodium, the molecular weight is $\frac{23 \times 100}{43.4} = 53$ if only one atom of sodium is present in the molecule. According to the conventional method the first step in the reasoning is to say that since 43.4 grams of sodium are present in 100 grams of substance there must be $\frac{43.4}{23} = 1.89$ gram atoms of sodium in 100 grams of material.

Mr. Stone comes in contact with boys who are not as a rule going to study chemistry after he is through with them and it is quite natural with such pupils to attempt to draw analogies between chemical problems and interest problems but there seems to be little choice between the two methods of reasoning and the inference which one draws on reading Mr. Stone's paper, that his method is a *more logical* one, does not seem to correspond to the facts. It starts with an assumption that is not true in many cases whereas the older method starts with an assumption that is always true.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

WILLIAM T. HALL

FURTHER QUESTION

In a recent publication of the JOURNAL OF CHEMICAL EDUCATION appeared an article which advocated the teaching of an ingenious, yet circuitous, method for the calculation of empirical formulas in preference

[1] THIS JOURNAL, 5, 465 (Apr., 1928).

to the present usually accepted method. The objection raised against the present method is that the steps in the solution do not seem to parallel those employed in common problems involving percentage and principle.

However, if the teacher advises the beginner to conceive of the composition of the compound in terms of grams per 100 for each element when the composition is given in per cent, as do many authors of elementary texts, the logic of the present method will at once become evident. Furthermore, no confusion will result from any preconceptions about percentage problems because no percentage is involved.

The important reason why all authors of chemistry texts adhere to the older method instead of following such a procedure as suggested by Mr. Stone is that the former goes directly to the solution of the problem, while the latter necessitates the calculation of two intermediate sets of figures, *B* and *C*, which represent the composition of the substance just as do the original data.

The relative amount of work required by the two methods for the derivation of the empirical formula of a compound from possible experimental data can best be illustrated by the example given below.

COMPOSITION OF COMPOUND BY WEIGHT

Carbon	0.3768 g.
Hydrogen	0.0319 g.
Oxygen	0.0871 g. by difference

A—PRESENT METHOD

$\frac{0.3768}{12} = 0.0313$ atomic weights of carbon in 0.4958 g. of substance

$\frac{0.0319}{1.008} = 0.0306$ atomic weights of hydrogen in 0.4958 g. of substance

$\frac{0.0871}{16} = 0.00544$ atomic weights of oxygen in 0.4958 g. of substance

$\frac{0.0313}{0.00544} = 5.8$

$\frac{0.0306}{0.00544} = 5.8$

$\frac{0.0544}{0.00544} = 1$

Therefore, formula is C_6H_6O.

B—STONE METHOD

$\frac{0.3768}{0.4958} = 0.76$ or 76% carbon

$\frac{0.0319}{0.4958} = 0.0643$ or 6.43% hydrogen

$\frac{0.0871}{0.4958} = 0.1757$ or 17.57% oxygen

$\frac{12}{76} \times 100 = 15.79$ multiple or submultiple of molecular weight which contains 12 g. or 1 atomic weight of carbon

$0.0643 \times 15.79 = 1.015$ g. of hydrogen in 15.79 g. of substance

$0.1757 \times 15.79 = 2.774$ g. of oxygen in 15.79 g. of substance

$\frac{12}{12} = 1$ atomic weights of carbon in 15.79 g. of substance

$\frac{1.015}{1.008} = 1.007$ atomic weights of hydrogen in 15.79 g. of substance

$\frac{2.774}{16} = 0.173$ atomic weights of oxygen in 15.79 g. of substance

$\frac{1}{0.173} = 5.8$

$\frac{1.007}{0.173} = 5.8$

$\frac{0.173}{0.173} = 1$

Therefore, formula is C_6H_6O.

E. I. DU PONT DE NEMOURS & CO., INC.,
WILMINGTON, DELAWARE

CARL Z. DRAVES

"THE REPLY COURTEOUS"

My small adventure in chemical arithmetic has evoked an unexpected animation from those in "the seats of the mighty." Their animadversions add vivacity to days which otherwise might become jejune. I am inveigled by the criticism offered but make my first bow to Prof. Hall.

When I saw the word "clever" in his criticism I was surprised, but when I looked up the definition in Webster I was overwhelmed. I am not worthy of such a Niagara of commendatory synonyms. I expect this compliment will cost me a cigar when next I meet the Professor.

In justice to my school, I must correct two erroneous assumptions. Prof. Hall assumes that the method I put forward is taught in my classes. My article does not say so and it is not true. It has not been thought good pedagogy to teach a method at variance with that in the text.

He assumes that the method was evolved to suit the intelligence of the boys with whom I am "in contact and who, as a rule, will not study chemistry further after I get through with them." Good joke, Professor. No doubt when I get through with them some, at least, will have been permanently cured of the desire to study chemistry any more.

Our school catalog lists the course I give as C4 and states that the course is open only to college preparatory boys. It is true that some of those who register for my course soon prove their ineptitude and relapse into a Nirvana of innocuous futility. But of those who come through with credit a considerable proportion may be found later in such gymnasia of cerebral activities as: Harvard, Tufts, Boston University, Northeastern, while a goodly number matriculate at the Institute of Technology where Prof. Hall has long served with such success. The records of these boys in freshman chemistry are on file at the Institute and the record is doubtless open to my critic's inspection. Take a look, Professor.

I may add that I can now name some ten or twelve of my boys who have taken their Ph.D.'s in chemistry at the Institute; some of these are now on the instructional staff of such institutions as University of Iowa, Brown, Boston University, Tufts, Cornell, and several others are associated with Prof. Hall on the teaching staff of the Institute. Many others survived only the B.S. degree.

My friendly critic rightly computes 1.89 for the gram-atoms of sodium and I add 0.94 and 2.82 for carbon and oxygen. We may now compare the concepts below and consider which is the more readily understandable by Jane and Johnny.

Old method		Proposed method
1.89 gram-atoms of sodium		1 Na atom
0.94 gram-atom of carbon	or	1/2 C atom
2.82 gram-atoms of oxygen		3/2 O atom

Since one gram-atom of sodium is 23, Johnny may reason that 1.89 gram-atoms means 23×1.89. (I wonder if Prof. Hall ever taught high-school students.) That abstruse calculation yields 43.47, an impossible number for the weight of sodium in any compound. Sadly but firmly we disentangle Johnny from that idea and show that dividing by 0.94 gives the numbers 2, 1, and 3. Multiplying the proposed values by two gives the same result.

Prof. Hall uses the term "gram-atom." I do not find this in the index of nine different recent and widely used high-school texts. Three of them give "gram-atomic weight" which is what is meant probably. I question if the term "gram-atom" is commonly used by teachers of high-school chemistry.

My friend says that a method should rest upon an assumption that is universally true. My assumption is that one molecule of any compound must contain at least one atom of each of the elements composing it. Is that universally true? What exceptions are known?

Comes also Dr. Draves who says that per cents can be expressed in parts per hundred. Of course. My article dealt with solutions from the given

per cents and with the logic of the procedure. In *A*, Dr. Draves shows a solution which ignores the points of my article and abandons his own proposal by using values which are neither per cents nor parts per hundred. Two of my colleagues, experienced teachers of chemistry, did not recognize Dr. Draves' method as conforming to the type of problem in our texts. We all grant the accuracy of his method, but accuracy is not the question under discussion.

In *B*, my Delaware friend piles Pelion on Ossa in the attempt to make my little mole-hill of a proposition look like a mountain. He assiduously arranges a series of sorites seeming to show a circumlocutory situation and labels the result "Stone method." I appreciate the generosity but must disclaim much of the material as not mine.

1. Three computations are given in *B* to show the derivation of per cents. There is no basis for this in my article which stated that the per cents were given. They *are* given in our school texts; they *are* given in the College Entrance examinations. Nobody is expected to solve for per cents first, before solving for the formula.

2. In all his computations Dr. Draves uses values to the fourth and fifth decimal place. This is far beyond the accuracy required of high-school pupils. His values are apparently derived from a laboratory weighing. If he expects students to obtain such results in high-school laboratories, he has set them an impossible task. Few schools are equipped with balances weighing beyond 0.01 g. Any weights below that would be so unreliable as to be useless. Realizing this, the best teachers of chemistry frown upon the use of such attenuated values and consider as wasted the time spent by pupils in working with them. My critic is using the laboratory results obtained by the trained chemist. Is it reasonable to expect untrained youngsters to be equally skilful?

3. The next three lines are acceptable barring the use of such decimals.

4. The remainder of the computations seems unnecessary. Surely we do not need laboriously to prove that 12 divided by 12 equals 1 or that 1 goes into 1 once. It must be a singularly inapperceptive pupil who could not determine such obvious facts at a glance.

Deleting the computations for determining the per cents, not necessary since *the per cents are given in the problem;* excising needless arithmetic; and expressing values in familiar terms rather than in fine-spun decimals, the problem stands as below, using Dr. Draves' formula and the per cents: C, 76.6; H, 6.4; and O, 17.0.

$\frac{12}{0.766} = 15.7$ assumed molecular weight if molecule contains 1 C atom

$15.7 \times 0.064 = 1$ or 1 H atom

$15.7 \times 0.17 = 2.66$ or 1/6 O atom

Multiplying by 6 gives 6, 6, 1 or C_6H_6O.

The pages of THE JOURNAL may serve better purpose than recording debates between individuals. I am grateful for the criticisms offered but, so far as I am concerned, the discussion ends here. Nobody is bound to use my method. The accuracy of the accepted method has not been questioned; only its logic from the standpoint of the high-school student has been examined. And it still remains not disproved that simple problems in formula determination from the given per cents may be solved by a method not the accepted one, accurately and simply, and without such an army of figures as Dr. Draves has assembled, ostensibly under my gonfalon, but certainly not all soldiers of mine.

Cheerfully yours,
CHARLES H. STONE

Children Get Ultraviolet Rays in Glass Pavilion. One of the first convalescent pavilions to be enclosed completely with glass that admits the ultraviolet rays of sunshine has been put up at the Stannington Sanatorium for Consumptive Children in Northumberland.

An anonymous donor contributed the money for the glass, which costs several times as much as the ordinary variety, so that child sufferers from the white plague could receive their daily allotment of sunshine without being exposed to the rigorous north-of-England winter. Though treatments with artificial rays from mercury arc lights are given at the sanatorium, according to Dr. T. C. Hunter, director, the glass pavilion 70 by 25 feet wide enables many small patients at a time to utilize hundreds of hours of sunshine that would otherwise be wasted.—*Science Service*

Light-Sensitive Cell Measures Healing Ultraviolet Rays. Radio amplification now is to be of service in the field of medicine. Prof. Ernst A. Pohle, University of Michigan Roentgenologist, in collaboration with Walter S. Huxford of the physics department, has designed a measuring device for ultraviolet rays, independent of other radiation which comes from quartz lamp or other light source.

In recent years ultraviolet light has come to be recognized as a cure for rickets and possibly for other diseases, but there has been no accurate means of measuring the quantity with which the patient is treated.

Up to the present time the photo-electric cell, one means of measurement, has required precision apparatus too complicated for the average physician to handle. Prof. Pohle and his associate have designed one that is simple and dependable. In it a radio amplifier is used to magnify an extremely small electric current so that it can be read on an ordinary switchboard galvanometer. The current comes from a photo-electric cell, which turns light into electricity.

Only ultraviolet rays between certain definite wave-lengths are believed to have any beneficial effect upon the patient, so it was necessary to develop apparatus which would measure only light of that wave-length, disregarding both longer and shorter waves. For this purpose the metal cadmium has been utilized by Dr. Pohle and Mr. Huxford because it is most sensitive to the waves long enough to affect the skin. The glass which they use in their cell cuts off longer light waves.

Dr. Pohle and Prof. Ralph A. Sawyer have also succeeded in calibrating the photo-electric cell in absolute units. This makes any recorded dose reproducible.—*Science Service*

Chemical Digest

ABSTRACTS

The Improvement of College Instruction. M. E. HAGGERTY. *Sch. and Soc.*, **27,** 25–37 (Jan. 14, 1928).—The author feels that contrary to general opinion much of the criticism directed at present-day education is unwarranted. Statements to the effect that instruction has deteriorated and the percentage of poor teachers is on the increase are likewise without authoritative foundation. The creation of certain additional educational values and standards is necessitated through the increasing demands made on the schools. The college must be able to account for its failures as well as for its successes—its teaching must be ably done.

The aims of the college are, unfortunately, not generally clear and teaching methods are misunderstood—all of which tend to lessen the effectiveness of the college. Several principles for the improvement of college instruction are discussed. Research, the author says, is essential to efficient college instruction and its program should be lengthened considerably. The ranking method of reporting student achievement offers a means of assigning meaningful grades and should have preference over the present system of marking technic which is practically worthless. The writer discusses the fallacy of present ideas and purposes of examinations and says that both college teachers and administrators have failed to recognize the importance of carefully prepared examinations and of the necessity of assigning grades which have some significance. Hence the recommendation here made for replacing exams. by objective measures of student achievement. Although not perfect, many of the existing defects would be eliminated. The work of many of the Committees of the Association is reviewed. K. S. H.

Notes on Vacuum Distillation in the Laboratory. F. H. MCDOWALL. *Chem. and Ind.*, **47,** 211 (Feb. 24, 1928).—Attention is called to the apparatus designed by Wade and Merriman (*J. Chem. Soc.*, **99,** 984 (1911)) for the purpose of adjusting to, and maintaining, any pressure desired for vacuum distillation. A diagram of the distillation system, incorporating this regulator, as used by McDowall, is given. Interruption of the distillation for the removal of samples is easily accomplished. E. R. W.

How Does a Nerve Function? R. W. GERARD. *Univ. of Chi. Mag.*, **20,** 193–6 (Feb., 1928).—Author's experiments in measuring very minute quantities of heat, gases, etc., indicate that the generally accepted belief that nerves conduct a "something," but themselves are passive, is wrong and that there are very definite physico-chemical changes in nerve itself comparable to changes in muscular tissue during and after functioning. B. H. B.

How It Is Done by the Chemist. D. B. KEYES. *Sci. Mo.*, **26,** 217–21 (March, 1928).—A description of methods of industrial chemical research. Illustrations are given of how waste products are changed into useful ones, improvements are made in a product, and equipment is utilized for the manufacture of other substances than that intended. G. W. S.

The Elements and Safeguards of Scientific Thinking. ELLIOT R. DOWNING. *Sci. Mo.*, **26,** 231–43 (Mar., 1928).—An extensive and detailed discussion of the methods of scientific thinking. A number of historic instances of scientific thinking are related and the different types of reasoning are described. Safeguards were discussed under the following heads: ideas of accuracy, observations must be extensive, observations under varying conditions, picking out essential elements, importance of dissimilarities, exceptions always significant, wide range of experience, consider all possible hypotheses, allow only one variable, skill in arranging data, pertinency and adequacy of data, the unprejudiced attitude, impersonal judgment, and suspended judgment. G. W. S.

A National Necessity. D. A. REED. *J. Natl. Educ. Assoc.*, **17,** 92 (March, 1928).—Mr. Reed, Chairman of the Committee on Education, U. S. House of Representatives, discusses the need of a Department of Education with a Secretary in the President's Cabinet. A. E. C.

The Relation of Secondary Schools to Colleges. A. L. LOWELL. *Sch. and Soc.*, **27,** 247–50 (March 3, 1928).—Dr. Lowell sets forth some significant facts regarding the increase in teacher's salaries in the last 25 years. While such increases may be due in

part to a fall in the value of money, yet it is generally conceded that education is becoming more and more expensive.

American colleges, unlike European, are burdened with instruction of a secondary nature. Our education starts late and proceeds slowly with no thought of the pupil whose goal is many years off—consequently American youth enters upon a profession later than he should or is deprived of several years of instruction which European youth is privileged to enjoy. American educators have failed to consider the student as an individual and have given him a smattering of many subjects rather than a thorough grasp of any one.

Voluntary coöperation on the part of the pupil is essential if the best results are to be obtained. It is far better to instill in a student a sense of responsibility and to stimulate him into voluntary effort on his part than to attempt to make education attractive and smooth as has been the aim heretofore. K. S. H.

Faculty Self-Survey and the Improvement of College Teaching. C. C. ECKHARDT. *Sch. and Soc.*, **27**, 336–8 (March 17, 1928).—The object of a self-survey recently conducted by six faculty members at the Univ. of Colorado was to get a correct evaluation of the work of the college as a whole as well as of individual teachers and to get constructive criticism that would result in more effective methods. The results were so satisfactory that it was decided to maintain a standing committee which would carry on a continuous self-survey. A list of the questions used is appended. K. S. H.

Methods of Appointing University Teachers. ED. EVENT. *Sch. and Soc.*, **27**, 290 (March 10, 1928).—The obligations of universities to professors and vice versa are discussed with the recommendation that a code of ethics be formulated by the Amer. Assoc. of Univ. Profs. and that any violations of this code be published. K. S. H.

Teaching of the Sciences. NICHOLAS MURRAY BUTLER. *Bull. Am. Assoc. Univ. Profs.*, **14**, 201 (March, 1928).—The writer believes that scientific training and scientific method, despite all the time, labor, and money that have been lavished upon them, have thus far failed to take hold of the minds and temperaments of vast numbers of those who have been given such training. He states that even scientific men themselves when removed from their laboratories often become victims of rumor, dogmatic assertions, and emotional appeals of every sort.

Science has been suffering from a superiority complex which has prevented it from realizing its true place in the scheme of things, the writer believes. In addition to this superiority complex, science has been in a large part poorly taught and is badly taught today. The scientific field into which the student is entering should be, first of all, described and its relations to the other sciences, with the main lines of its historic development, explained to him. The student with these views has redoubled interest because he sees himself dealing with a vast and continuing human interest. E. L. M.

Methods—or the Spirit of Method? M. MARK. *Wash. Educ. J.*, **7**, 196 (March, 1928).—The ultimate purposes of all teaching is to develop the native capacities of the child, to fit him for his social environment and yet not make him its victim. The form of method must be varied because each child is an individual, and the same child is different at various stages of development. A new method is not always good and should be used only when it makes possible the application of the fundamental laws of learning. If teachers consider their method as the end, rather than as a means to an end, it is impossible to understand the viewpoint of fathers and mothers. In conclusion, teachers must seek to develop a true sense of method, one that will serve us rather than enslave us; the needs of the child must govern our procedure; these needs are widely variable, and to perceive them requires keen discernment through constant study; among teachers' needs is that for a broad, sensible, flexible "spirit of method" capable of sensing how individual are the many youthful personalities with which we deal. A. E. C.

The New Education Bill. V. K. FROULA. *Wash. Educ. J.*, **7**, 197–8 (March, 1928).—The facts that six per cent of our total population is illiterate and that only twenty-five per cent of the teachers of the entire country have what is considered the minimum preparation for teaching make education a matter of national as well as state concern. At the present time the Bureau of Education is not in a position to attack research problems that are needed to promote education. Different departments make over thirty separate appropriations for educational activities. Such unrelated activities for the same cause cannot help resulting in waste and inefficiency. The bill before Congress leaves the control of schools to the several states and local authorities and does not in any way interfere with private or sectarian schools. At the present time we have developed a national system of education without national control by means of general information about the best current practices. It is unjustifiable to

contend that any provision for the efficient conduct of a public enterprise inevitably leads to control of that enterprise. Research is necessary for progress. This has been proved in industry. Education is not only as important as agriculture, commerce, and labor, but is actually fundamental to each of these. The States Rights argument against the Education Bill has no solid basis. A. E. C.

Retirement Fund Conferences. S. E. FLEMING. *Wash. Educ. J.*, **7**, 199 (March, 1928).—General impressions, which Mr. Fleming gathered at the joint conference of the Committee of One Hundred on Teachers' Retirement Funds of the N. E. A. and the National Council of Teachers' Retirement Systems at Boston in February, are: (1) In the East an adequate teachers' retirement system has been accepted as an essential condition for an efficient state system of schools; (2) the various problems involved in the setting up and operation of teachers' retirement systems are clearly recognized and are being solved; (3) that the promotion of sound teachers' retirement systems is one of the major projects of the N. E. A. and that effective leadership to that end is being given; (4) that the situation in the State of Washington holds out fewer obstacles than have been overcome in most of the older states. A. E. C.

Hydrogen-Ion Concentration. W. M. SCOTT. *Dyestuffs*, **29**, 33–7 (March, 1928).—Hydrogen-ion concentration is a new tool which chemists have developed, and simplified for practical use in many industries. The three following pamphlets are recommended for obtaining a working knowledge of this tool: "The A B C of H-Ion Control," published by the La Motte Chemical Products Company; "Measuring H-Ion Concentration," published by Leeds and Northrup; and "The Determination of Hydrogen Ions," by W. Mansfield Clark.

In a solution of an acid the proportion of ionized hydrogen determines the degree of acidity and not the normal or molar concentration. Instead of using numerals for expressing hydrogen-ion concentration, it is expressed as the logarithm of $1/C_h$ and this value is termed the pH. The pH of a neutral solution at 22°C. is 7, acid solutions vary from 7 to 0 and alkaline solutions from 7 to 14.

Dilution does not affect the pH of an acid as much as we might expect. For instance, the pH of 0.1 *N* HCl is 0.1 and of 0.0001 *N* HCl is 4.01. It is possible to dilute strong acids, *i. e.*, H_2SO_4, sufficiently, for them to have a pH within the range of common acetic acid solutions; it is impossible to concentrate acetic acid so that it will have a pH equal to that of 0.1 *N* HCl. In practice, in place of varying pH by dilution, salts are added. This is known as buffer action.

Salts may be used in this way, because salts of acids and bases of unequal strength do not give neutral solution. Upon hydrolysis they give either basic or acidic solutions depending upon whether the hydrogen-ion concentration is increased or decreased in comparison with the hydroxyl-ion concentration. It is possible to obtain a pH between 7 and 1 by mixing sulfuric acid and sodium acetate in different proportions; it is possible to obtain any pH between 7 and 13 by mixing sodium hydroxide and monosodium phosphate in different proportions. Certain organic chemicals are also used as buffers.

Hydrogen-ion concentrations are usually measured by electrometric or colorimetric methods. The electrical method is based upon the use of the unknown solution as an electric cell and ascertaining the voltage, which is set up by this cell. This voltage is correlated with the hydrogen-ion concentration of the solution. The colorimetric method is based upon the color of an indicator in a solution of a definite pH value. A definite amount of indicator is added to the solution and this is compared with known solutions of equal volumes.

Applications of hydrogen-ion analysis and control in the textile industry are very numerous. In purifying water by alum, the best flocculation in the shortest time occurs at a pH between 6 and 8. The pH should be determined in the following operations preliminary to dyeing: (1) scouring of cotton or wool, (2) soaking of silk, (3) degumming of silk, (4) carbonizing of wool, (5) mercerizing of cotton, (6) bleaching of cotton, wool, or silk, (7) desizing of cotton. The definite principles which have been established with regard to the action of acid or basic dyes on silk or wool are: (1) the amount of acid dyestuff absorbed by silk or wool from a solution of given initial concentration increases with the hydrogen-ion concentration of this solution; (2) the amount of basic dyestuff absorbed by silk or wool from a solution of given initial concentration decreases with an increase in the hydrogen-ion concentration of this solution: (3) in acidified dyebaths the amount of acid dyestuff adsorbed by the silk or wool at a given initial hydrogen-ion concentration is constant and is not dependent on the absolute amount of acid used to obtain this hydrogen-ion concentration. References given. A. E. C.

The Riddle of Roentgen Rays. A. H. COMPTON. *Univ. of Chi. Mag.*, **20**, 250–6

(March, 1928).—An article developing the growth of the idea of waves of light and also the corpuscular theory of light; with the suggestion of a dualistic nature for light.
B. H. B.

The Art of Soap Manufacture. T. PENNY. *Chem. and Ind.*, **47**, 258–64 (March 9, 1928).—An illustrated article, giving a little of the history of soap making, some information as to the peculiar properties of the different soaps, and considerable detail as to the methods of manufacturing and blending of soaps. The article should be of interest to beginning students of chemistry as well as to those with much more training. E. R. W.

Chemical Warfare and Its Relation to National Defense. ANON. *Chem. Warfare*, **14**, 292–4 (March, 1928).—People should not confuse the question of preparation for war with the question of prevention of war. The prohibition of any particular practice of war has no bearing on the prevention of war. The value of chemical warfare as an agency of war has been conclusively proved in the recent world struggle. Because of the part which the chemical industries must play in this field in time of war it is important that they be developed and supported in the different nations. Without such industries a nation would be at the mercy of those having such a weapon.

"When war comes, peace mentality fades into nothing and the dreadful seriousness of war itself is recognized." "At such a time, however, it is too late to overcome the handicaps which ill-considered peace-time actions create." E. R. W.

Spectra and Atoms. ANON. *Nature*, **121**, 341–2 (March 3, 1928).—A lecture outlining the relations existing between series of lines in the spectra of elements and discussing the harmony of these relations with the theories of the electronic configuration of the atom, as well as electron orbits. T. M. M.

Popular Science. EDITORIAL. *Nature*, **121**, 349–50 (March 10, 1928).—In America the task of reporting, correctly and in a way interesting to the average newspaper reader, the doings of scientific societies, and the results of research, is in the hands of Dr. E. E. Slosson, director of the Science Service, Inc. In Great Britain, while scientific knowledge is disseminated to the initiated there is still a need for its presentation to the lay reader. Dr. Slosson has found archeology and astronomy most popular among the sciences, to his public. T. M. M.

Letters to the Editor. E. NIGHTENGALE, A. K. GOARD, F. S. YOUNG, AND H. E. A. *Nature*, **121**, 453–5 (March 24, 1928).—E. N., while agreeing with the general purport of the editorial by H. E. A. appearing in *Nature* of Feb. 25th, objects that the editor is not using the scientific method he urges on others, when he makes the too sweeping statement that no attempt is made in the schools to teach that method. F. S. Y. agrees that H. E. A. has overstepped the bounds of fact and has exaggerated the lack of method taught in the schools, though he agrees with the criticism that there is not sufficient coöperation between the schools and universities.

A. K. G. feels *Nature*, as a magazine read by school and college faculties, should continue to urge coöperation in the setting of standards for entrance. He stresses the impossibility of the masters finding time to teach both method and the tremendous quantity of facts required at the examinations; facts far too advanced for students of their age. H. E. A. maintains that he differs from the above correspondents probably in his definition of "scientific method," which he uses in the broad sense in its application to ordinary life and to ourselves. He does not blame the teachers who are tools of the class lacking the scientific viewpoint. He merely wishes to point out their inability to express themselves clearly and entertainingly and still scientifically. He offers to present a report on the problem of entrance examinations and coöperation between the schools and colleges on their requirements, at the next meeting of the Science Master's Association at Cambridge. T. M. M.

The Need for Standards in Courses in the Teaching of General Science. J. O. FRANK. *Gen. Sci. Quart.*, **12**, 431–43 (March, 1928).—In so far as information could be obtained, there are at least seventy different courses in the U. S. dealing with the teaching of general science. There is extreme variation in the courses of general science. Eight types of variation are enumerated, with accompanying analysis. Five bad effects of lack of standards are given. Author thinks that much good would come of a definite sequence of courses in college for science teachers. Such a sequence is proposed as a basis of discussion and a point of departure for future committees. (*A*) "Teachers Course in General Science," on a college level and giving two credits; (*B*) "The Teaching of General Science," two credits; (*C*) "Methods of Investigation of Problems Involved in the Teaching of General Science," a strictly graduate course. Each of these courses is discussed at length. J. H. G.

Three Centuries of Natural Philosophy. W. F. G. SWANN. *J. Frank. Inst.*, **205**, 1–18 (Jan., 1928); reprinted in *Gen. Sci. Quart.*, **12**, 444–60 (March, 1928).—The great

scheme of nature's laws has never been so unsparingly unfolded as in our generation. If all time from the dawn of history to the present were shrunk into a day, twenty-three hours of that day are barren as far as natural philosophy is concerned; it is only in the last hour that science was born. Three hundred years ago scientific thought was founded largely upon the writings of Aristotle. A good example of misty philosophizing is the proof given by one of the disciples of Aristotle, "The bodies of which the the world is composed are solids and therefore have three dimensions. Now three is the most perfect number; for, of one we do not speak as a number, of two we say both; but three is the first number of which we say all. Moreover, it has a beginning, a middle, and an end." The hypotheses, assertions and discoveries of Galileo, Francesco Sizzi, Isaac Newton, Kepler, Faraday, Clerk-Maxwell, J. J. Thomson, Roentgen, Becquerel, Rowland, Michelson, and others are given and used in the argument. Discarded theories must not be considered as useless. Nor is all discovery at an end. When we have a period rich in new discoveries, followed by a period of apparent stagnation, we should no more think that science is dead than we could have confidently voiced that same thought in the civilization of the Pharaohs; or in the years which followed Newton; or perhaps as we would have voiced it, yea, perhaps did voice it thirty years ago—then let us take hope. There is more in heaven and earth than is dreamed of in even twentieth century philosophy. J. H. G.

Elementary Science in English and American Schools. C. M. PRUITT. *Gen. Sci. Quart.*, **12**, 461–6 (March, 1928).—Science occupies a relatively minor part in the elementary school curriculums of England and the United States. Time allotment and nomenclature in both countries are discussed. The purposes of science in the English elementary schools are quoted from "The Board of Education Suggestions to Teachers." Nature study is divided into the Infant, Junior, and Senior stages. A typical nature study syllabus of a city infant school in England is given. J. H. G.

Scales for Rating Pupils' Answers to Nine Types of Thought Questions in General Science. C. W. ODELL. *Gen. Sci. Quart.*, **12**, 467–76 (March, 1928).—Ten answers with criticisms and evaluations are given to type question V. "Discuss the development of the Pure Food Laws." Ten answers with criticisms and evaluations are given to type question VI." "Tell how a siphon works." J. H. G.

The Chemist's Faith in the Invisible. B. C. HENDRICKS. *Gen. Sci. Quart.*, **12**, 477–80 (March, 1928).—The chemist makes most of his discoveries by the splendid exhibition of faith in the invisible. Examples are made by considering the fat globules in milk; oil-water emulsions; smoke precipitation; the deposition of molecules of tungsten on the glass in incandescent lamps; the preparation of Ehrlich's "606;" Madame Curie's discovery of radium; the glowing bulb in the radio receiving set is a monument to the inventor's faith in the electron. Is the chemist less able to find help in a faith in the Unseen Supreme in his religious world of thought? "Whatever the answer to this question, the student who chooses chemistry as his chief interest in college, does not get very far in its perusal before he realizes that one of its most important demands is a working faith in the realm beyond his senses, peopled by colloids, molecules, atoms and electrons." J. H. G.

Industrial Motion Pictures. ANON. *Gen. Sci. Quart.*, **12**, 484–6 (March, 1928).—Three important new industrial motion picture films have been recently added to the collection of films possessed by the U. S. Bur. of Mines, Dept. of Commerce—The Story of Petroleum; The Story of Iron; The Story of the Fabrication of Copper. The Bur. of Mines has probably the largest collection of educational industrial motion picture films in the world. Distribution of the films is centered in the Bureau's Experiment Station in Pittsburgh, Penna. There are thirteen subdistribution centers. The names of these are given. The films are loaned; no charge is made for use of the films; exhibitor must pay transportation charges; the titles of forty-six films now available are given. Borrowers are asked to write to the subcenter distribution station nearest them. Descriptive lists may be obtained from the Pittsburgh Station. J. H. G.

Wanted—A Word to Replace "Believe." E. C. L. MILLER. *Science*, **67**, 319 (March 23, 1928).—The expression "I believe" does not adequately express the scientific attitude of mind. Its use in scientific literature is misinterpreted by unscientific readers particularly because of the religious significance of the expression. G. H. W.

Forty American Books—1926. AMERICAN LIBRARY ASSOCIATION. *J. Natl. Educ. Assoc.*, **17**, 127–8 (April, 1928).—Reviews of forty books are given. They are listed under the headings, general, social science, religion, philosophy and psychology, belles lettres and art, drama, biography, science, natural and applied. A. E. C.

The Secondary School. A. T. FULLER. *J. Natl. Educ. Assoc.*, **17**, 121–3 (April, 1928).—In all types of education, we should provide for the child the kind of training

and the type of discipline that will help him to grow to the fullness of his stature as a man. Business desires that the lower schools should help the boy to understand his obligations to the social, civic, and economic community, of which his life is to be a part, and his duty to himself to "play the game." In the future, institutions will make provision for training for business pursuits. These technical courses should be tested with reference to their actual usefulness in the occupations for which they prepare. Technical knowledge is secondary to the development of essential qualities. First, the boy should understand that nothing can overcome a fundamental weakness of moral fiber. Second, he should acquire a certain ability in meeting issues and in making decisions. Third, he should have a pervading and honest respect for work, and be prepared to render a full measure of it. A. E. C.

The Commission on the Curriculum. CURRICULUM COMMISSION. *J. Natl. Educ. Assoc.*, **17**, 119 (April, 1928).—A report of the Commission is made which is given in full in "The Development of the High-School Curriculum." A. E. C.

The Boston Resolutions. COMMITTEE ON RESOLUTIONS. *J. Natl. Educ. Assoc.*, **17**, 117–8 (April, 1928). A. E. C.

Teachers' Salaries—The Future. J. K. NORTON. *J. Natl. Educ. Assoc.*, **17**, 107–8 (April, 1928).—Teachers' salaries are not likely to increase a great deal in the next few years. A continuance of present tendencies would mean that the average salary of teachers would stabilize at a figure between 60 and 70 per cent of the average income. Teachers' salaries may drop from their present position among incomes in general, to their position before the war. High standards cannot be required for admission to a service which promises an economic return substantially below that of other callings. A. E. C.

Democracy in Education. W. H. P. FAUNCE. *J. Natl. Educ. Assoc.*, **17**, 103–4 (April, 1928).—Democracy is freedom—not identity or similarity. It is not a leveling-down or a leveling-up process. Each pupil should have his talents developed to the best of his ability. In teaching the pupil, the teacher should consider not where he came from, but where he is going to; not who his parents are, but whom he will become. If teachers are to stimulate their pupils, they must be growing personalities themselves. A. E. C.

Growth through Mental Hygiene. W. H. BURNHAM. *J. Natl. Educ. Assoc.*, **17**, 105–6 (April, 1928).—The subject of most importance today for the teaching profession and for the individual teacher is that of mental hygiene. No preparation for the teacher's work equals the training in the principles of a sound scientific mental regimen. This has a three-fold value for the development of the teacher's personality: namely, by its aid to the individual teacher in the care of his own mental health and in the ability to rise above the emotional handicaps, inhibitions, and enslaving habits which have survived from an older conception and an older condition of the teacher's calling; by its new point of view enabling the teacher to see the real value of the essential doctrines of education; by its higher and stimulating ideal for the teacher's calling. A. E. C.

Review of "Educational Measurements." MARY REAVES MAULL. *High Sch. Teacher*, **4**, 170 (April, 1928).—Fenton and Worchester's book on "Educational Measurements" has been reviewed. Facts in regard to the measurement movement which are likely to be of practical value in the classroom activities or in other contacts with children are given. The types of tests which are available are pointed out and discussed as to their construction, standardization, and reliability. An entire chapter is devoted to the meaning and value of intelligence tests. The uses of achievement tests for the improvement of teaching efficiency are shown. The new type examinations and their daily use in the classroom are discussed and a comparison of old and new types and their advantages given. The authors point out other important phases of the educational measurement movement such as measure of special abilities, character traits, emotional stability, nervous symptoms, and general physical stability. E. L. M.

World's Deepest Mine. O. LETCHER. *Compressed Air Mag.*, **33**, 2389–91 (April, 1928).—An interesting description, well illustrated, of the Village Deep Gold Mine in the Union of South Africa. The workers in this mine have reached a depth greater than that reached anywhere else in the world. The Turf Shaft of this mine extends 7630 feet below the datum line, or 1800 feet below sea level. The temperature of the rock of this depth is about 97°F., the air is cooled by means of ice to 85°F. Four tons of ice are used every 24 hours in order to accomplish this cooling. Because the air is kept so much cooler than the rock at this depth there is continual contraction and scaling of the rock sides of the shaft. E. R. W.

Local Activities and Opportunities

The Pennsylvania State College. Dr. J. Bennet Hill, Chief Research Chemist of the Atlantic Refining Company, addressed the local section of the American Chemical Society, Wednesday evening, May 2nd, on the subject, "Recent Developments in the Petroleum Industry." The enormous increase in the consumption of gasoline, the insistent demand for a gasoline of greater non-carbonizing and anti-knocking properties, and the great need for more fundamental research in petroleum hydrocarbons were some of the topics discussed. Dr. Hill pointed out that the chemical phases of petroleum refining will be developed more in the future, since in the past the trend of development has been along engineering lines. He mentioned also that our organic chemistry has been devoted more to the aromatic field for two reasons (1) because the subject was first developed in Germany where coal is a more important resource than petroleum, and (2) because the aromatic compounds afford a more satisfactory source of productive research.

Dr. C. A. Shull, professor of plant physiology at the University of Chicago, gave an illustrated lecture on the life and work of Stephen Hales at the meeting of A. A. A. S. (local section), known as the Penn State Science Club, on Wednesday evening, May 10th. Stephen Hales is regarded as the father of modern plant physiology.

The Taylor Instrument Company of Rochester, New York, recently exhibited a very complete display of scientific instruments manufactured by them. The exhibit was very interesting and instructive for all students and workers in science.

Plans are now completed for an addition to the first unit of the Pond Laboratory of Chemistry. This addition will cost $250,000 and construction will be started this summer. The first unit which now contains the divisions of quantitative analysis and physical chemistry, was built about ten years ago. It is hoped that funds for the completion of the building as originally planned will be appropriated in the near future.

Nebraska. The State Academy of Sciences met at Fremont, April 26–28th. The program of interest to chemistry teachers was:

FRIDAY EVENING—APRIL 27TH

8.00 P.M.

Address—"The Food Problem in China," Dr. William Henry Adolph, University of Nebraska.

SATURDAY MORNING—APRIL 28TH

"The Teaching of Chemistry," W. F. Hoyt, Peru Teachers College.

Chemistry Section

PROF. A. C. RICE, Grand Island College, *Chairman*

FRIDAY—10.30 A.M.

"Oxidation of Discard Molasses from a Beet Sugar Factory," B. J. Hites, Chemistry Department, Grand Island College.

"The Recitation—Lecture in Chemistry," J. C. Blake, Midland College.

"The Synthesis of 4-Methoxy-3,5-dinitrobenzene-sulfonic Acid," Warren H. Steinbach, B. C. Bren, Organic Chemistry Department, University of Nebraska.

"Improved Methods in Organic Preparations," Organic Chemistry Department, University of Nebraska.

(*a*) "Ethylene and Ethylene Dibromide," Max Karrer.

(*b*) "Williamson's Synthesis—Isopropyl-Butyl Ether," Paul R. Shildneck.

SATURDAY—10.30 A.M.

"Study of Nitrogen Partition in Liver Hydrolysis," E. A. Fluevog, W. H. Adolph. University of Nebraska.

"An Iodine Survey of Nebraska," F. J. Prochaska, W. H. Adolph, University of Nebraska.

"The Permeability of Metals to Hydrogen," R. R. Ralston, B. Clifford Hendricks, University of Nebraska.

"Finding and Salvaging Superior High-School Chemistry Student—Exploratory Studies," P. G. Johnston, B. Clifford Hendricks, University of Nebraska.

High-School Teachers Section

GRANT L. STAHLY, Hastings High School, *Chairman*

SATURDAY—10.30 A.M.

I. "How Much Science Should Be Required for High-School Pupils?" Earl Schoer, Omaha Technical High School.

II. "The Importance of Equipment in Teaching High-School Science," M. P. Brunig, Agricultural College, University of Nebraska.

General Discussion.

III. "Needed Revisions in the High-School Course of Study" (the discussion for each subject was led by a member of the committee of revision).

Physics—Prof. Herbert Brownwell, University of Nebraska.

General Science—Superintendent W. E. Hager, Cozad.

Chemistry—J. J. Guenther, Omaha Technical High School.

Biology—Mary Sturmer, Beatrice.

Dakota Wesleyan University. The fourth annual science open house was held on the afternoon and evening of April 27th. Extensive exhibits were presented by the departments of biology, chemistry, geology, home economics, and physics. Dr. T. C. Stephens, head of the department of biology of Morningside College at Sioux City, Iowa, spoke on "Warblers of the Missouri Valley." Over one thousand visitors, including over two hundred high-school students from adjoining cities, attended.

Wm. F. Filbert, a senior who has been student assistant in the department of chemistry for the past fifteen months, has received a teaching assistantship at the University of Minnesota. He will enter upon his new duties about September 15th. He graduates with highest honors on June 1st.

The third annual Chemistry and Home Economics Industrial Tour was held on May 7th. Ten important industrial plants of Sioux Falls, S. Dak., were visited.

Instructors from all science departments were present at the annual meeting of the South Dakota Academy of Science which was held at Huron, S. Dak., on May 4th and 5th.

Cincinnati Section, A. C. S. The 299th regular meeting of the Cincinnati Section of the American Chemical Society was held in the Chemical Auditorium of the University of Cincinnati on May 9th, at 8 o'clock.

The speaker of the evening was Dr. Martin Fischer, professor of physiology in the Medical School of the University of Cincinnati, who lectured on "Lyophilic Colloids in Theory and Practice."

The Kentucky Association of Chemistry Teachers held its seventh meeting at Louisville, Ky., on April 21st.

The program follows:

1. Inspection of Louisville Girls High School Chemistry Department.
2. Inspection of exhibit "Relation of Chemistry to Industry," displayed by pupils of Louisville Girls High School.
3. Welcome and invitation to A. C. S. regional meeting in Lexington in October—Dr. V. F. Payne of Transylvania College, Lexington.
4. "The Refining of Petroleum"—Mr. Louis F. Hertz, Head Chemist of Standard Oil Company of Kentucky.
5. Report of A. C. S. meeting in St. Louis—Miss Marie Borries, Head of Chemistry Department of Louisville Girls High School.
6. "Individual Laboratory Work versus Lecture Demonstration"—Dr. V. F. Payne.
7. Business meeting and election of offi-

cers. Dr. V. F. Payne, Transylvania College, Lexington, Ky., President; Mr. W. L. Williams, Henderson, Ky., Vice President; Miss Pauline K. Stein, Louisville Girls' High School, Secretary-Treasurer.

Columbia University. The Charles University at Prague has lately conferred upon Dr. Marston T. Bogert the degree of "*Rerum Naturalium Doctor*," which may be translated as "Doctor of Natural Sciences." As this university is the oldest in Europe east of Paris and north of Italy, the honor is one to be highly regarded indeed.

Two of the lectures which Dr. Bogert delivered at the Charles University were published in the February and April numbers, respectively, of THIS JOURNAL and a note on Dr. Bogert's life and achievements is included in the Editor's Outlook of the latter number.

University of Pittsburgh. Professor Alexander Silverman, head of the department of chemistry of the University of Pittsburgh, sails May 18th on the Tuscania for a three-month tour of Europe.

During the first month, Professor Silverman will be with the American Ceramic Society on its European Tour. The remainder of the time will be spent in countries not covered by the Ceramic Tour. Professor Silverman will visit educational institutions, museums, and glass factories in France, Switzerland, Italy, Austria, Germany, Czecho-Slovakia, Belgium, The Netherlands, England, and Scotland. He expects to acquire numerous glass specimens for the collection at the University.

N. E. A. C. T. The following officers of the New England Association of Chemistry Teachers were elected for the year 1928–1929, at its regular meeting on May 12, 1928.

General officers:

President—Joseph S. Chamberlain, M. A.C., Amherst, Mass.

Vice President—Elwin Damon, H. S., Keene, N. H.

Secretary—Octavia Chapin, H. S., Malden, Mass.

Assistant Secretary—Martin G. Sanborn, H. S., Everett, Mass.

Treasurer—Shipley W. Ricker, H. S., Woburn, Mass.

Advertising Manager—Alban Fowler, H. S., Arlington, Mass.

Auditor—S. Walter Hoyt, Mechanic Arts H. S., Boston, Mass.

Curator—Lyman C. Newell, Boston University, Boston, Mass.

Division Chairmen—Western, G. Albert Hill, Wesleyan University, Middletown, Conn. Southern, Arthur H. Berry, Classical H. S., Providence, R. I. Northern, Benj. R. Graves, H. S., South Portland, Maine. Central, Roland B. Hutchins, Classical H. S., Lynn.

Senate of Chemical Education—Maine, C. A. Brautlecht, U. of Me., Orono; E. Sutermeister, S. D. Warren Co., Cumberland Mills; Stephen P. Gould, Edward Little H. S., Auburn. New Hampshire, G. A. Richter, Brown Company, Berlin; George Perley, Univ. of N. H., Durham; Wilhelm Segerblom, Phillips Exeter Academy, Exeter. Vermont, P. C. Voter, Middlebury College; Otto Winestock, Perkinsville. Massachusetts, J. S. Chamberlain, Mass. Agricultural College; G. J. Esselen, 276 Stuart St., Boston; Laura P. Patten, Medford H. S., Medford. Rhode Island, Norris W. Rakestraw, Brown University; A. H. Fiske, Rumford Chem. Works, Providence; Frank W. Greenlaw, Rogers H. S., Newport. Connecticut, G. A. Hill, Wesleyan University; Elbert M. Shelton, Cheney Bros., Manchester; Harry S. Wessels, Middletown.

Contributing Editors to the Journal of Chemical Education—Maine, C. A. Brautlecht, Univ. of Maine. New Hampshire, E. B. Hartshorn, Dartmouth College. Vermont, S. F. Howard, Norwich, University. Massachusetts, S. Walter Hoyt, Mechanic Arts High School, Boston. Rhode Island, R. R. Thompson, Cranston H. S., Auburn, R. I. Connecticut, Grover C. Greenwood, W. G. Harding H. S., Bridgeport.

Program of the 110th meeting at Concord, N. H., Saturday, May 26, 1928.

10.30—Address of Welcome. The Reverend Samuel S. Drury, D.D., L.H.D., Rector of St. Paul's School.
Response. Alfred M. Butler, President, N. E. A. C. T., Practical Arts High School, Boston, Mass.
11.00—"Solutions and Colloids." Charles H. Stone, Chemistry Department, English High School, Boston, Mass.
12.00—"Some Noteworthy Achievements in Chemistry in 1927." Vice-President Elwin Damon, Keene High School, Keene, N. H.
12.30—Demonstration by Cambridge Botanical Supply Company.
1.10—Luncheon—St. Paul's Cafeteria.
2.00—Business Meeting—Report of Committees.
2.45—Visit to points of interest about St. Paul's School.

Carnegie Institute of Technology. Recreational and entertainment plans for the students are receiving special attention from the officials in charge of the summer courses at the Carnegie Institute of Technology in Pittsburgh, according to an announcement. In addition to the regular features such as swimming in the Institute's pool, tennis, popular lectures, and inspection trips, plans for the coming summer also include dances, picnics, a boat ride, musical programs, and receptions.

Excursions and visits to the industrial plants and to various points of interest in the Pittsburgh District, a popular feature of former years, will again constitute an important part of the recreational plans. The trips are considered to be of special interest to the student or teacher of industrial processes. The Carnegie summer session will open on June 11th, this year for courses for teachers and supervisors of Music, Fine and Applied Art, Manual and Industrial Arts, Psychology and Education, and for courses in engineering and industrial subjects for undergraduates.

Although the courses for teachers are six weeks in length, beginning June 25th, arrangements may be made for the first time this year, it is announced, to take preliminary courses of two weeks' duration in certain subjects beginning June 11th.

Rutgers University. The following graduate students have won appointments to fellowships in other universities both at home and abroad. Alfred T. Hawkinson, at present Instructor in the department, M.A., Rutgers, 1927, has been appointed to a German-American Exchange Fellowship at the University of Breslau. Robert E. Hulse, at present an assistant, has been awarded the Grasselli Fellowship at Cornell University. F. E. Kopecky has won a fellowship at Harvard.

Dr. Walter C. Russell, assistant professor of biochemistry in the College of Agriculture, attended the convention of the American Society of Biological Chemists at Ann Arbor, April 14–16th. He presented a paper by Russell, Massengale, and Howard on "The Duration of the Effect of Ultra-Violet Radiation on Chickens."

Dr. James Kendall, Dean of the Graduate School of New York University, addressed an open meeting of the Society of Sigma Xi, Monday evening, May 14th, on the subject "Separation by the Method of Ionic Migration." The lecture was well attended and aroused considerable discussion.

The staff of the chemistry department for the coming year is complete except that there remains to be appointed one assistant. The appointee is expected of devote approximately half his time to laboratory supervision and the other half to graduate work. The position carries exemption from all tuition fees besides a stipend.

Massachusetts Institute of Technology. At the Massachusetts Institute of Technology a new laboratory of Inorganic Chemical Research has been organized and with the opening of the Fall term will begin active operation.

The establishment of this laboratory arises from a realization of the need of more adequate facilities than have previously prevailed at the Institute for original work in inorganic chemistry. It

is true that the different branches of chemistry—inorganic, physical, organic, and electrochemistry—overlap to such an extent that single research often invades the domain of all of these branches. Nevertheless, it is true that the great interest in recent years in the more specialized lines has drawn attention away from the fundamental importance of inorganic chemistry.

New and improved methods of preparation of already known substances, as well as work with the rarer or less well-known elements; the revision of erroneous data which have been copied, oftentimes over a period of many years, in various works of reference; preparation and investigations of new classes of substances which have hardly been studied at all; little studied types of inorganic reactions, especially in non-aqueous solvents; the technic of reactions which must be carried out *in vacuo* or in inert gas atmosphere—these are some of the lines in which research in inorganic chemistry has been perhaps neglected, and to the solution of such problems the activities of the laboratory will be devoted.

Attention is called to the fact that graduate students desirous of working for a Master's or Doctor's degree in inorganic chemistry will find the facilities to this end available in a measure not hitherto possible, with the opening of the new laboratory. The members of the Division of Inorganic Chemistry will be associated in guiding the work of such graduate students, and a system of weekly conferences will provide the means for discussion of the work in progress.

Further details relating to the opportunities offered to students contemplating graduate work in this field may be obtained by inquiring of Professor W. C. Schumb, Massachusetts Institute of Technology, Cambridge, Mass.

A pamphlet of abstracts of scientific and technical publications during 1927, containing in part 51 papers published by 31 members of the chemistry department, some of these men having published five papers or more, has just been published by this institution. In addition, six doctorate theses were included.

Western Reserve. A graduate assistantship at $500.00 is available for anyone desiring to work in the field of catalysis.

University of Buffalo. H. Milton Woodburn, instructor in chemistry, has a leave of absence, to complete the work for his Ph.D. at Northwestern.

Dr. H. W. Post has been advanced to the rank of assistant professor.

Prof. A. P. Sy, Prof. E. R. Riegel, and Mr. H. Milton Woodburn are spending the summer in Europe.

Middlebury College. Dr. Charles F. H. Allen, of the chemistry department of Tufts College, has been engaged to take charge of the organic chemistry in the Middlebury College summer session, school of chemistry. This school is one of the few and probably the first to give a full-year course in all chemistry subjects during the summer session.

University of Tennessee. Plans for a new unit for the department of chemistry are near completion. The bids will be let about July the first and actual construction should be under way in the middle of summer. The new unit will house all the departments except that of elementary general chemistry, which will occupy its present quarters in addition to that vacated in Science Hall by the remainder of the chemistry department as well as the departments of physics and geology. At the completion of this building program the department will be amply supplied with general and private laboratories, offices, lecture-rooms, and private research rooms.

The appointments for the fellowships in the department of chemistry for the year 1928–29 have been made. The recipients are:

F. H. Stubblefield, University of Tennessee; Henry A. Dickerson, Mississippi College; Gilbert Kinney, Arkansas College; J. H. Wood, Eastern Kentucky Teachers College.

Recent Books

Principles of Chemical Engineering. WALKER, LEWIS, AND MCADAMS. McGraw-Hill Book Co., Inc., New York, 1927. Second edition. ix + 770 pp. 14.5 × 23.0 cm. $5.50.

A second edition of this pioneer technical work is welcome. It is valuable to advanced students, and engineers and manufacturers. The authors clearly state the purpose and scope of the work and have demonstrated the reality of chemical engineering to those who have misunderstood it.

Before the issue of the first edition there were two notions current regarding chemical engineering. One stressed the adjective "chemical" and the other stressed the noun "engineering."

The latter or advanced view had a relatively small group of adherents. This was quite natural. To the extent any thought at all is given to the matter by the adherents of the chemical idea they are probably still in the majority. This is connected with the fact that chemical engineering as a branch of engineering or even as a name or ideal, owes its origin to teachers of chemistry rather than to engineers. The engineering profession did not welcome the newcomer. To be sure the engineering family had grown. The ancient branch, civil engineering, as distinguished from military engineering, eventually had separated from it in the course of industrial development of the world, specialized forms of engineering, with whose details the civil engineer found it burdensome to maintain an adequate experience in view of the continued and ever-increasing demands for civil engineering proper. The old original divisions which were separated from civil engineering and were well recognized in the formative period of modern engineering education in the last fifty years or so, were: mechanical engineering, mine engineering, and eventually electrical engineering. Some of us can still remember the old degree of Mechanical Engineer in Electrical Engineering, thus illustrating how these divisions originated. Shortly thereafter the teachers of chemistry, in the universities and technical schools, recognized the handicap both to graduates and to the industries in maintaining engineering in a separate compartment in the applications of chemistry in manufacturing. The inferiority complex on the part of the graduates was overcome by insistence upon the teaching of a new branch of engineering known as chemical engineering.

These teachers built wiser than they knew. They naturally emphasized chemistry perhaps unduly, because of its real importance. The engineers in other branches of engineering felt that with a little chemical advice (and this generally precious little), they could adequately handle all the engineering questions. The teachers of chemistry were compelled therefore to force the teaching of chemical engineering upon the engineering colleges. There is at least one great university to this day in this country, in which the engineering college does not include the curriculum in chemical engineering. It is operated by the arts college. There are a few institutions also whose chemical leadership has not appreciated the need for chemical engineering teaching, and who have attempted with many evidences of real success to supplement sound chemical teaching with engineering drawing, mathematical and thermodynamic subjects, so that the graduate handles himself so capably with the problems he meets, that formal engineering training has not been instituted.

This quite natural situation will gradually find real assistance in the healthy development of engineering education in the

last three decades. Therefore, chemical engineering education is in ever-increasing demand. This office has had inquiries in the last few months, for over forty Ph.D.'s with a foundation in chemical engineering, which could not be filled. It should always be remembered by both the engineering educator and the chemical educator that the best interests of two parties is involved in an educational point of view regarding industry; first, the graduate, and second, the industrial development of the nation. It is not enough therefore to have a healthy attitude regarding proper teaching of fundamental science. This ought we to do. There are other things, however, which ought not to be left undone. It is not enough that a surgeon have a well grounded training in physiology and anatomy. These ought he to have, but he must be trained also in the connecting up of these sciences with the need for doing something effective to or for a patient who is in extremity. To be sure, anyone with a map of the human anatomy could perform an operation for appendicitis and perhaps even successfully, but it would be a tragedy for the patient if we were permitted to do so without that knowledge and training which is connected with the application of certain fundamentally important sciences to the situations which arise when the human ox is in the ditch. Hence the emphasis on medical education. Hence, also in a similar way the emphasis for the last forty years on engineering education. There is nothing that an engineer or a lawyer or a doctor does which anyone else of equal personal intelligence could not also do. But when the emergency arises all of us prefer the services of the individual who has specialized in training himself not only in the foundation sciences but in the experience of the race in putting these sciences to work.

The authors of this text are to be congratulated as pioneers in crystallizing this branch of engineering. One may not always agree with nomenclature, points of view, or characteristics, but the work is a great contribution to engineering. The book is remarkably free from bases for criticism especially in a pioneer work which blazed its own trail.

It is quite natural that such a pioneer book will strive perhaps unduly to throw much theory into its point of view and the practical man will without doubt be able to point his finger at more than one such case, for after all has been said and done, we eventually turn to the old empirical factor of experience. It is always difficult for us to realize that not every one possesses our own experience or can make adequately our own empirical estimates, and I suppose also when we make blunders on this basis, we have plenty of alibis. The young generation of engineers will make more rapid progress into that safe, empirical basis, and perhaps a better empirical basis, when they have at hand the scientific and theoretical bases of engineering provided in this work. At any rate adequate and engineer-like design requires as much of mathematical precision as can be worked into experience. This alone justifies the labor of the authors. The gaps they disclose in our precise knowledge constitute fine suggestions for research, for being precise in this field is the most difficult of any engineering field because of the disturbing chemical factors, as well as the ordinary engineering variables.

The first edition of Walker, Lewis, and McAdams "Principles of Chemical Engineering," included: Industrial Stoichiometry; Fluid Films, Flow of Fluids; Flow of Heat; Fuels and Power; Combustion; Furnaces and Kilns; Gas Producers; Crushing and Grinding; Mechanical Separation; Filtration; Basic Principles of Vaporization Processes; Evaporation, Humidity, and Wet and Dry Bulb Thermometry; Humidifiers, Dehumidifiers, and Water Coolers; Drying; and Distillation. The second edition includes all of these and adds two new sections: General Principles of Fusion Processes; and Absorption and Extraction, increasing the total number of pages from 637 to 770. The

first third of the book remains practically the same and there is but small total expansion in the first two-thirds of the book, the new sections occupying about ninety pages.

The authors clearly indicate that the various chemical engineering operations ("unit processes!" "unit operations!") have much in common, but if the underlying principles upon which rational design of basic types of engineering equipment depend, are understood, their adaptation to engineering processes becomes a matter of good management.

The book is bound to be a great help to the elimination of mere building as against designing of equipment and the elimination of large scale experimentation after erection. The authors endeavor to simplify labor by the use of simplified terms and units. Problems are included to emphasize the organization of data. Great stress is laid upon the flow of heat and the flow of liquids and upon the efficient combustion of fuel. Graphical methods of computation are substituted for complicated algebraic technic of the first edition in handling rectification. An appendix contains a list of problems for solution. On some of the subjects experience has rapidly accumulated and advantage is taken of it in the second edition.

The use of any good book can be abused, even an engineering book, although perhaps the abuse in an engineering case is not entirely a waste. The temptation with a book of the nature of that by Walker, Lewis, and McAdams, is to turn its teaching over to a young man on the staff with merely a good training in physical chemistry and facility in mathematics, but with no engineering or even manufacturing experience. As a result the student thinks he is getting chemical engineering and does not realize at the time what he is missing, for the instructor himself does not know and the whole course degenerates into a course in physical chemistry merely, with the advantage that it is at least applied. Even this objection brings the ameliorating thought that perhaps much physical chemistry teaching would profit if it used this book as a basis, or at any rate it would be a valuable aid if not a first-class substitute for the material used perhaps rightly enough, in the classical treatment of physical chemistry, if one is going further into that subject.

Teachers of industrial chemistry have been developing in their own courses fundamental principles of chemical engineering. Teachers of chemical engineering have been developing fundamental principles which they have found from their own experience in manufacturing and have developed without doubt nomenclature to fit their experience. These will now be strengthened by the teaching of this book if judiciously used.

In connection with terminology the writer of this review has been using in the chemical engineering work in this (the Ohio State) University for the last 22 years, the term "engineering operations," to cover such operations as filtration, distillation, condensation, calcination, or whatever engineering steps require special design in equipment (*J. Amer. Chem. Soc.*, **33**, 624 (April, 1911) (Educational Supplement)). The work under review at times uses the term "operations."

It was with regret however that we found the terminology "unit" and "processes" used in the work in connection with engineering operations such as filtration. Undoubtedly, these words could be used in the connection indicated. By "unit," however, the engineer usually means a single piece of equipment such as a steam boiler, as a unit in a battery of boilers, or a dynamo, a unit in a series of dynamos. The word "processes" too is unfortunate in that it would be quite unreasonable for chemical engineers to take a word already well established in chemistry and give to it a different or a not entirely clear meaning. We have the LeBlanc Process, the Ammonia Soda Process, the Twitchell Process, the Krebitz Process, the nitrogen fixation processes, and many others. These matters are obviously not vital, but they do contribute

to the clearness, especially to beginners and those not acquainted with technical terms and even prevent blunders among technical men themselves.

As a suggestion to individuals who have developed their own courses independently of and before the advent of this work, the experience of the writer may serve as a way of introducing their students to the point of view of the book. We have not used the book as a text, but have recommended it as a personal reference possession. We have then assigned to the individual students different chapters or sections in the book as "Reports from Our Consulting Chemical Engineers, Walker, Lewis and McAdams," whose technical details and mathematics we wish to have explained in detail for all of our "Works Staff." This problem requires the student to thoroughly study and digest the section assigned and gives him practice in reducing scientific and technical engineering material to the level of the ordinary business or factory staff.

The authors of this work have gone extensively into the theoretical basis of some of the chemical engineering operations. To some, this mathematical treatment will appear extreme, particularly when resort was inevitably made to empirical factors. The men in the industry should not expect too much of theoretical science or become discouraged when they find it does not sound the depths which they are compelled to do from time to time when facing a concrete problem for which industry demands a solution. The authors have made a notable effort to balance theory with their own actual engineering experience.

It does not take much of a prophet or much engineering experience to realize that the whole field of engineering is destined to more and more turn to chemical engineering for assistance. This text should therefore be a valuable work in the hands of every civil, mechanical, electrical, or other engineer dealing with changes in materials whether chemical or physical.

JAMES R. WITHROW

First Report of the Committee on Photochemistry. H. S. TAYLOR, *Chairman;* W. D. BANCROFT, G. S. FORBES, H. G. DE LASZLO, S. C. LIND, LOUIS A. TURNER. Reprint and Circular Series of the National Research Council, Number 81. 95 pp. 17 × 24.5 cm. $1.00.

Reprinted from *J. Phys. Chem.*, **32**, 481–575 (April, 1928). The papers included are: Introduction. H. S. Taylor. 1 p. Experimental Technique for Quantitative Study of Photochemical Reactions. George Shannon Forbes, 21 pp. Absorption Coefficients. Henry G. De Laszlo, 4 pp. The Excited Systems Formed by the Absorption of Light. Louis A. Turner, 9 pp. Quantum Processes in Photochemistry. Hugh S. Taylor, 13 pp. The Displacement of Equilibrium by Light. Wilder D. Bancroft, 44 pp. Relation between Photochemical and Ionization Reactions. S. C. Lind, 3 pp.

Wearing Apparel: Its Manufacture, Utility, Selection, and Care. A series of seven radio talks. Radio Publication No. 37. University of Pittsburgh, Pittsburgh, Pa., 1928. 62 pp. 15 × 22 cm. 50 cents.

The titles of the talks included are as follows:

1. Cotton Fabrics. C. F. Goldthwait.
2. Undergarments. Edgar R. Clark.
3. Wool Clothing. Lloyd E. Jackson.
4. Silk Garments. Helen E. Wassell.
5. Rayon Goods. George H. Johnson.
6. Furs. Lloyd E. Jackson.
7. Hats. Rob Roy McGregor.

The contents of this publication should be of especial value to persons who are desirous of acquiring an elementary knowledge of textiles. It should also be helpful to teachers of home economics and elementary chemistry.

Laboratory Manual of Colloid Chemistry. HARRY N. HOLMES. Second edition. John Wiley and Sons, New York, 1928. xviii + 228 pp. 23 × 15 cm. $3.00.

The chapters are entitled: suspensions—coarse and fine; dialysis, diffusion, and ultra filtration; condensation methods of preparation; dispersion methods of preparation; electrical properties, electrical osmose, and electrophoresis; coagulation or flocculation; protective colloids; surface tension—interfacial tension; emulsions; froths and films; solvated colloids or gels; soaps; the colloid chemistry of proteins; reactions in gels; viscosity and plasticity; adsorption from solution; adsorption from gases; aerosols; soils and clays; special topics.

The author has covered a great deal of ground and he has covered it very well. In the preface to the first edition he says that "most of the experiments have been tested in the laboratory course given at Oberlin for the past six years" (written in 1922). The reviewer wonders whether adding saponin to the capillary tube in the sedimentation experiment, p. 12, is really helpful. One would have supposed that the high surface viscosity would have made trouble.

On p. 24 the author quotes from Kahlenberg. "It should be stated here that not only does cholestrine possess these selective osmotic properties, but phytosterine, the analogous non-saponifiable ingredient of plant oils, also shows practically the same properties. Since cholesterine is present in all living animal cells, it would seem likely that *it is extremely delicate films of these sterenes that give living cells their wonderfully selective osmotic properties.* Moreover, since animal oils contain cholesterine and all plant oils similarly contain phytosterine, one would naturally expect membranes made of such oils to exhibit selective osmotic properties to some degree, especially when relatively considerable amounts of these sterenes are present. This, too, has been found to be the case."

While congratulating the author on his book, the reviewer is a little skeptical about the hope implied in the statement, p. v.: "So much theory has been interspersed between the experiments that the manual is now almost a text as well." It is doubtful whether a laboratory manual ever can or should function as a textbook. There is nothing about this book to make one change this dictum.

WILDER D. BANCROFT

Surgeon Calls Spleen Electro-Magnetic Filter. Another explanation of the purpose of the spleen, the organ that the ancients removed from their runners to give them, theoretically, better wind, has been advanced by Dr. William L. Robinson of this city.

The function of this mysterious organ that many people seem to get along very well without, is a sort of electro-magnetic filter, according to Dr. Robinson, that removes from the blood such waste particles as broken-down red blood cells, certain colloidal toxins and negatively charged bacteria. This conclusion is based on experiments in the course of which compounds containing negatively charged silver and platinum and positively charged copper were administered to experimental animals in the laboratory. The first two elements were eliminated through the customary channels but the copper was retained, Dr. Robinson explained, by the electro-magnetic properties of the spleen acting as a filter.

Sometimes the spleen becomes enlarged from causes not clearly understood at the present time and its removal by operation becomes necessary. Of 500 subjects of such operations performed at the Mayo Clinic at Rochester, Minn., between April, 1904, and March, 1928, 80 per cent are still living, Dr. William J. Mayo has reported. Only ten per cent died while in the hospital and the remainder have either died from other causes or are unaccounted for.—*Science Service*